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The Profession of Chemistry

by

RICHARD B. PILCHER, O.B.E.
Registrar and Secretary.

FOURTH EDITION

Prepared under the supervision of the Publications Committee of the Institute

30, RUSSELL SQUARE, LONDON, W.C.1
1938

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The first edition of this book was published by Messrs. Constable & Co., London, in 1919.

Subsequent editions have been prepared by the Registrar under the supervision of the Publications Committee of the Institute. The Committee has received valuable advice from several Fellows of the Institute, to whom various chapters have been referred.

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INTRODUCTION

To the Second Edition

By Professor Arthur Smithells, C.M.G., D.Sc., F.R.S.,
Past President of the Institute of Chemistry.

This publication is issued to meet a constant demand for information about the profession of chemistry. It is a new edition of the book written by the Registrar and published in 1919. The first edition being exhausted, the Registrar very generously asked the Council of the Institute to accept the copyright of the book and undertook to revise it, under the supervision of the Publications Committee, in order that it might find a place among the official publications of the Institute.

The events of recent years have profoundly affected the profession. In the science itself, apart from its practical applications, there has been an outburst of new knowledge that makes the subject more than ever attractive to the student. The work of the engineer and the architect is constantly before the public; the medical man, the solicitor and the accountant, can scarcely be avoided in everyday life; but until the close of the last century, those who practised chemistry as a profession were, comparatively speaking, very few, and their work was so much less obvious that the importance of chemistry was hardly recognised.

In its practical application the stimulus has come largely from the catastrophe of war. During the perilous years 1914–1918 the safety of our country and of civilisation made unprecedented calls upon chemical science not only for providing the munitions of war, but for providing us with the essentials of life. The war left us a crippled industrial nation, whose recuperation, it has been declared on every side, must largely depend on the application of science, and chiefly of chemistry, to our manufacturing arts. It is natural, therefore, that there should have been a rush of the younger generation to the profession of chemistry. We, who are in it, have been constantly asked to advise parents how their sons may become chemists.

In spite of all that chemistry has done, the vast majority of people are still very ignorant of the character and purpose of

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the science, and still more ignorant of what is involved in the education and work of a chemist. It is becoming better understood that there are different kinds of chemists and that those who are devoted to the science in its widest aspects are not merely concerned with analysis. It is not easy to get people to appreciate the many considerations that should receive attention before entering the chemical profession if the right course is to be taken and disappointment avoided. The disregard of this has led in many instances to young men and women preparing for a chemical career who from defects of talent and training or other disadvantages have found themselves unable to obtain employment. There is probably no profession that more needs explaining. Like most others, it is overcrowded with aspirants, and the worldly prospects are poor for those who are not well equipped. It must be emphasised that it is in the main an employed profession—that is to say very few of its members are independent practitioners, and the majority do not occupy high positions of control. Yet it demands brains of a high order, hard work, and considerable sacrifice.

In these circumstances, it is clearly desirable that the public should be provided with an authoritative guide in which they may find information clearly set forth on the subject of a chemical career, and it is fitting that this book, which is admirably suited to serve the purpose, should be published at a time when the Institute has just completed 50 years of its existence, and when the views expressed on the matters dealt with have, in the main, become generally accepted.

ARTHUR SMITHELLS.

3rd October, 1927.

INTRODUCTION
To the Third Edition

By Professor Jocelyn F. Thorpe, C.B.E., D.Sc., F.R.S.,
Past President of the Institute of Chemistry.

The second edition of this book appeared in 1927, the year of the celebration of the Jubilee of the foundation of the Institute. Information regarding the profession of chemistry is increasingly sought, especially by parents and students, and the book, which deals comprehensively with the subject, has proved to be of great value. This edition, carefully revised, is published in the year of the Jubilee of the Incorporation of the Institute under Royal Charter.

I cordially endorse the commendations of Professor Smithells.

JOCELYN THORPE.

April, 1935.

INTRODUCTION
To the Fourth Edition

By Sir Robert H. Pickard, D.Sc., F.R.S.,
President of the Institute of Chemistry.

I am glad to have the opportunity of commending this book.

The prospects of a career in chemistry have improved since Professor Smithells wrote the Introduction to the second edition.

The profession continues to increase numerically, and yet it is not overcrowded, owing to the much extended employment of adequately trained chemists in industry, in industrial research organisations, and in the public service. Increased opportunities have also been due, particularly in recent times, to the more frequent promotion of chemists, qualified by personality and capacity, to posts of management and responsibility in industry.

No other book contains so much information of direct use to those who aspire to a career in chemistry.

ROBERT H. PICKARD.

June, 1938.

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PREFACE

THE importance of the science of chemistry can hardly be overrated. No branch of natural science can claim a closer connection with the material progress of mankind, and there is hardly a Department of State or other Public Authority, or an industrial or commercial undertaking of any magnitude, which does not benefit by its aid. So wide are the applications of the subject and so deep are its ramifications that it is certain to hold a prominent and increasingly important position in public affairs, in industry and in commerce, in all aspects of everyday life. For this reason there should always be a demand for chemical knowledge and ability of the highest order.

Following this preface are given synopses indicating the education and training recommended for the profession of chemistry, and the possible careers open to chemists. For the consideration of parents, and possibly of schoolmasters, the first chapter is devoted to the subject of preliminary education. The title "chemist" is then discussed, showing the distinction between chemists and pharmacists. Subsequent chapters deal with the technical training, examinations, and qualifications for the practice of analytical, consulting and technological chemistry; with post-graduate training and research; and with the societies and institutions concerned with chemical science. Next, the various branches of practice, and the prospects offered therein are considered; a chapter is devoted to the recognised procedure of members of the profession in their relations to one another and to the public; another, to the prospects open to women chemists, and the final chapter deals with scientific journalism and authorship.

The aim, therefore, is to review generally the position of the profession of chemistry; but it must be remembered that opinions are constantly changing on many of the subjects dealt with—e.g. education, technical training, and organisation—which obviously cannot be settled for all time, and will no doubt be modified with the trend of future developments.

R. B. P.

SYNOPSES OF
(A) THE EDUCATION AND TRAINING RECOMMENDED FOR THE PROFESSION OF CHEMISTRY
AND
(B) THE POSSIBLE CAREERS FOR A CHEMIST.

A. Education and Training.

General Education,—on as broad lines as possible, up to sixteen or seventeen years of age.

Matriculation or other recognised Preliminary Examination,—including English, Mathematics, at least one Foreign Language and one other subject. (A knowledge of German, as well as of another foreign language, is not only desirable, but, in many chemical appointments, essential.)

Professional Education,—day courses comprising Chemistry, Physics, Mathematics and at least one additional scientific subject:—

(*a*) Four years at an approved University, College, or Technical School; or

(*b*) At least three years at a University, College, or Technical School, and one year in a suitable laboratory or works.

In cases where sufficient means are not available to provide for systematic day training, the student may obtain experience in a laboratory or works and attend evening classes covering equivalent curricula in an approved Institution.

Qualifications.—A degree in Science or Arts, including Honours in Chemistry, with Physics as chief subsidiary subject, and Mathematics to the required standard, or a recognised College Diploma of equivalent standard.

The Associateship of the Institute of Chemistry (A.I.C.).

(An Associate may be attached to a Local Section of the Institute and, as soon as means allow, should become a member of one or more of the chemical societies: Chemical Society, Society of Chemical Industry, Society of Public Analysts, and, possibly, of one or more Societies interested in particular branches of Applied Chemistry or Chemical Technology.)

Higher Qualifications.—Those who are devoted to research should take post-graduate training for a higher degree such as M.Sc., Ph.D., or D.Sc. Others should seek experience in a suitable laboratory or works, or training in chemical engineering; and

After three years' approved study and practice as an Associate of the Institute of Chemistry, the chemist is advised to qualify, by examination or otherwise, for the Fellowship (F.I.C.).

B. Possible Careers for a Chemist.

(1) *Consulting Practice*, general or specialised: Assistant; Chief Assistant, with prospect of transferring to an appointment in industry; partnership, or independent practice; official appointment.

(2) *Industrial Practice*—

(*a*) Analytical Chemist: Junior Assistant; Assistant; possibly transferring to Research or to Plant Control, or becoming Chief Assistant or Head of Analytical Laboratory.

(*b*) Research Chemist: Junior Assistant; Chief Assistant; possibly transferring to Plant Control or becoming Head of Research Laboratory.

(*c*) Works Control Chemist: Departmental Plant Control; Process and Plant Research; Assistant Manager.

(*d*) Manager; Managing Director; Partner or Director.

(*e*) Consulting, Analytical, Research and Technological Practice; Chemical Engineering.

(3) *Official Chemical Appointments.*—The Government Laboratories and other Departmental Laboratories: Junior Assistant Chemist: Senior Assistant Chemist: Principal Assistant Chemist: Superintending Chemist: Deputy Chief Chemist: Chief Chemist.

Other Government appointments, technical, educational, etc.; Admiralty; War Office; Air Ministry; Board of Education; Ministry of Health, etc. Official Appointments in Overseas Dominions and Colonies.

Municipal, etc.: Assistant to Public Analyst; Public Analyst; Official Agricultural Analyst; Gas Examiner; Water Examiner; Chemist in Public Health Laboratory; Chemist to Sewage or Rivers Boards, etc.

Public Institutions, Industrial Research Associations, etc.: Research and Analytical Appointments.

(4) *Teaching*—

(*a*) School: as general Science Master or Chemistry Master (in Public or Secondary school).

(*b*) Technical Schools, Medical Schools, Agricultural Colleges, etc.: Assistant Demonstrator, Demonstrator, Lecturer (general or in a branch of chemistry,—inorganic, organic, physical, metallurgical, biological, etc.); Lecturer in Technology; Head of Department; Principal.

(*c*) University or College: Assistant Demonstrator; Demonstrator; Lecturer (general or special); Assistant Professor; Professor (general or special); Chair of University; Dean of Faculty and higher University appointments; Examinerships.

(5) Employment combining two or more of the above.

(6) Other employment in which chemical knowledge and ability are advantageous, through not necessarily the primary factors: the Bar, patent agency; journalism; commerce, etc.

THE PROFESSION OF CHEMISTRY

Chapter I

PRELIMINARY EDUCATION

Chemistry, as the science which treats of the composition of matter, is one of the chief keys to the study of nature. It is indispensable in the arts and manufactures and ancillary to many other branches of science.

The training of the mental faculties of those who intend to practise chemistry should be no less comprehensive than that prescribed for any other learned profession. The student who has a liking for science should not, therefore, at too early a stage, become absorbed in it to the detriment of his general development. A good general education is essential in every profession—using the term profession in the sense in which it is applied to medicine, the law, architecture, and the like—and it is advisable that anyone who intends to follow a professional career should remain at school until he has passed the School Certificate Examination, or Matriculation,—the Entrance Examination to a University. Students who pass a Matriculation or equivalent examination at 15 or 16 years of age, and even many who matriculate later, may find it advantageous to remain at school for a further two years and prepare themselves for a Higher School Certificate Examination, which, if the requisite subjects be taken, may be accepted in lieu of the Intermediate or First Examination for a Degree.

The present demand in all affairs of life is for practical good sense and trained intellectual capacity. The typical British public-school boy, whatever his shortcomings may be, has developed a straightforward and sturdy individualism invaluable to those who are destined eventually to occupy positions of responsibility and control; but education has become the common heritage of all classes, and public-school boys have to face the ever-increasing competition of those from the modern schools, to whom the earning of their living is an absolute and often an immediate necessity. With the introduction of free

primary education, the demand has arisen for a higher standard of both general and special knowledge in every grade of social life.

The public-school curriculum covers a comprehensive programme, including, in most cases, religious and ethical instruction and citizenship, the inculcation of a respect for law and order; English language and literature; Latin, and frequently Greek; French and, if not Greek, then another modern language; history and geography; mathematics; science; drawing; physical drill and athletics. The instruction given in some subjects may be somewhat limited, but, in no case, should ethics (moral discipline), languages, science (including mathematics) and athletics be neglected.

The study of our own language, in the past, was often treated so lightly that many were never able to write good English, or could not do so until they were well advanced in years. Essay writing might be practised occasionally, but generally the opportunities for composition were limited to the writing of exercises on school subjects and answering examination questions. The study of literature, on the other hand, was, and still is, promoted by reading Shakespeare, other poetry and plays, and the works of well-known prose authors.

In recent times, most public and secondary schools have taken English more seriously, although less attention is given to the *spoken word* than it deserves as an important factor in the life of a professional man or woman.

It is obvious that good composition cannot be expected of a pupil until he has acquired knowledge and formed definite ideas; yet the accurate use of English is often not sufficiently encouraged. Good reading—especially the reading of biographies and essays, when youths are old enough to appreciate them—is to be commended as tending to induce the habit of methodical thought and expression in writing and speaking.

In the secondary and private schools and in the majority of the universities a marked advance has been made in the direction of science teaching during the past seventy or eighty years. It has developed in many a real enthusiasm for knowledge of natural phenomena and has encouraged observation, intelligent enquiry and criticism. Its introduction, however, was gradual, not only because, at first, there were few teachers, but also on account of the alterations which had to be made in order to allow time for the study of the new subjects. In most cases

the time devoted to classical languages had to be curtailed to make provision for chemistry, physics, biology and the like. Recent deliberations on the place of science in pre-university education appear, on the whole, to suggest that all three subjects specified are now regarded as desirable in the Secondary School curriculum. The publication of the Report of the Science Masters' Association, embodying its final conclusions on the treatment of these three subjects in the curriculum, is expected shortly.

The difficulty of generalising on educational matters, however, can hardly be fully realised except by those who have to educate. The schools must of necessity have some regard to the temperament, bent and capabilities of individuals, since it is neither possible nor desirable that they should all be cast in one mould. It is sometimes questioned whether any special subject is advanced by its being made obligatory; but if attention to a subject is forced on a number of pupils there is a greater chance of finding some who will be attracted to it. In most cases there is a mental bias towards some form of knowledge which can be strengthened by judicious encouragement, but it is generally agreed that, so long as steady progress can be made, the education should be as "all-round" as possible. There is a danger that early specialisation may interfere with general development, and it is doubtful whether it is wise to encourage the study of any one branch of knowledge at the expense of others for the acquisition of which there is comparatively little opportunity when once the professional training has commenced. It is not unusual, however, to allow each individual a choice of subjects in the later stages of school life, in order that scope may be given to variations in natural aptitude.

In every intellectual calling, specialisation at the right time is not only profitable to the individual, but, in the higher stages, highly desirable in the interests of progress and efficiency. The difficulty lies in deciding the right time for, and the manner of, its introduction.

A parent or guardian can rarely be certain of selecting a calling which will be acceptable to an individual until the education of that individual has begun to make a marked impression on his character and inclinations. A broad knowledge of men and things does much to make a man "a good mixer," and no amount of technical knowledge can compensate for the lack of that in professional life. Furthermore, he must be respected, and

this he cannot be unless he acquires sound judgment. It is, therefore, safer in all cases, and more likely to be productive of satisfactory results, if he is educated on as broad lines as possible up to the threshold of manhood, bringing out the best that is in him, without particular reference to his future career. The broader the basis of his education, the better will be his general self-development and the greater the likelihood of discovering his special bent. To be a good runner or a good boxer needs something more than running or boxing: the whole body must be trained to secure efficiency. Similarly, a sound general education is necessary for the race and the contest of life.

While a good general education increases the chances of success of the average individual, defective general education in a professional man is a serious hindrance, and is likely to bring discredit on his calling. For all professional work the first essential is the existence of good men with high ideals, and the duty of producing such men rests very largely with the schools. The aim should be to secure an education which will exercise and cultivate the mental faculties, strengthen the character, the will, and the judgment of every citizen, and thus contribute to the strengthening of the character of the State.

When the individual has determined on a career in chemistry, he should possess sufficient knowledge of the subject to enable him to enter on the higher technical training for which provision is made in the Universities and Colleges. He will be required to matriculate, or pass a college entrance examination, before he can be admitted to the courses for a Degree or a Diploma. For registration as a Student of the Institute of Chemistry he will be called upon to produce a certificate of having passed an approved Preliminary Examination of matriculation standard in (*a*) English Language; (*b*) Elementary Mathematics; (*c*) at least one foreign language, and (if not more than one language) (*d*) Higher Mathematics or some other approved subject. It should be noted, however, that although only one foreign language is compulsory in a Preliminary Examination for the Institute, a useful knowledge of German and also of French, or some other language, is expected in the Examination for the Associateship (A.I.C.). This requirement is also usual in the University Examinations for the Honours B.Sc. Degree. Ability to read German is essential to a chemist, in view of the extensive chemical literature published in that language.

Chapter II

THE TITLE *CHEMIST*

The main purpose of this book is to deal with the education, technical training and professional work of those who practise chemistry in the capacity of analytical, consulting, technological and research chemists, or as teachers of chemistry. To all of these the title "Chemist" is logically applied; but in this country this title has come to be applied in popular usage to the pharmacist, who, after examination and registration by the Pharmaceutical Society, becomes legally entitled to describe himself as a "Chemist and Druggist" or "Pharmaceutical Chemist."

The fact that, in this country, the title *chemist* is used for the two distinct callings has led to much confusion of ideas. The general public having less acquaintance with the chemists with whom this book is concerned, and being accustomed to see the sign "Chemist" over every retail pharmacy, not unnaturally perhaps, assumes that every chemist keeps a shop for the sale of medicines. It is true that the rapid growth of applied chemistry, especially during the past twenty years, has led to considerable public enlightenment, but it may be expected that those who pursue the science of chemistry as a profession will find, for some time yet, that the true nature of their professional work is not invariably correctly understood.

It is desirable that the student should be acquainted with the history and present position of the title "Chemist" in this country.

The title "Chemist" is applied to the holders of official positions, such as Professors of Chemistry in the Universities and Colleges. The head of the Government Laboratory is the "Government Chemist," and of the Admiralty Laboratory, the "Admiralty Chemist," whilst many other officials, to whom reference will be made later, are engaged on chemical work and are styled "chemists." The representative body of persons engaged in chemistry is *The Institute of Chemistry*.

Modern dictionaries define *Chemist* primarily as one skilled or versed in the science of chemistry, and *chemistry* as the science of the elements and the laws which regulate their combination and behaviour under various conditions. The profession concerned herein is that of *chemistry* according to that definition and, in view of the remarkable advances made in chemical science and the vast ground it covers, it must be maintained that, if

any *chemist* deserves to use the title without any qualifying adjective, he should be a thoroughly trained all-round chemist, before all things a *chemist*, and he should so style himself.

The importance of the subject touches not only the interests of the profession which is mainly concerned. The science of chemistry claims so close a relation to the material progress of mankind, and its applications are so wide, that no effort should be spared to encourage a proper appreciation of its importance in modern life.

The Institute feels that, in the interests of a proper appreciation by the public of the services rendered by chemists in practically all productive industries, in commerce, and in the affairs of the State, every effort should be made in this country to use the word with its true significance.

The confusion does not exist elsewhere. These are the terms used abroad:—

	"Pharmacist"	"Chemist"
French	Médecin-pharmacien Pharmacien	Chimiste
Italian	Farmacista Apózicari	Chimico
Spanish	Farmaceutico Boticario Apoticario	Químico Chimista
Portuguese	Boticario Pharmaceutico	Chimico
German	Apotheker Arzneibereiter	Chemiker
Dutch	Apotheker Artsneijmenger	Chimist Scheikundige
Danish Norwegian	Apotheker	Kemiker *or* Chemiker
Swedish	Apotekare	Kemist
Russian	Aptickari Pharmatsicobi	Chimiki
Greek	Pharmachopoios Pharmakeutes Pharmakeus Apothēkē	Chemichos
United States of America	"Drug Store"	Chemist

From very early times alchemists (literally *the* chemists) devoted their attention to the science and applications of chemistry in a far wider field of interest than that which simply concerns medicine and pharmacy. They were chiefly philosophers, friars, physicians, the nobility and clergy, and were not usually associated with industry and commerce. They

sought the philosopher's stone for the transmutation of metals, and the elixir of life; and much of their work was directed to the investigation of minerals and metals. The awakening of knowledge regarding the nature of substances followed on the experience gained in many branches of industry—the working of metals, brewing, dyeing, ceramics, the manufacture of oils and soaps, etc.

The science of chemistry, as we know it to-day, cannot be said to have existed until the seventeenth century, when a beginning was made under the influence of such men as Boyle and Becher, to bring together the scattered facts of the alchemists and to reduce them to principles.

Towards the end of the seventeenth century, after the foundation of the Royal Society, chemists were classified by Bishop Spratt into three classes, namely, "such as look after knowledge of nature in general; such as seek out and prepare medicines; and such as search after riches by transmutation and the great elixir," so that the confusion of names in this country already existed (1667). It had been brought about largely through the apothecaries—originally dealers in roots, herbs, syrups, and the like—having acquired the right to practise medicine. The apothecaries then obtained their supplies from the druggists, who dealt in materials for the preparation of galenicals, and from chemists who prepared mineral medicines "by fire." These chemists also sought chemicals for use in industry and the arts, and may be regarded as the forerunners of the manufacturing chemists of the present day; but even they were distinct from the philosophers who pursued their investigations for the advancement of natural knowledge, for its own sake.

The *chemist* of that time did not dispense medicine; that was the province of the apothecary.

After the foundation of the Royal Society (1660), chemistry was the hobby of the highest in the land; King Charles II and Prince Rupert had their laboratories, and many of the nobility and men of rank took the keenest interest in the science. A dictionary compiled by John Kersey, London, 1708, defines *chemistry* as "an art which teaches to separate the different substances that are found in mixed bodies and to reduce them to their first principles," and *alchemy* as "that part of chemistry which more especially relates to the change of the form of metals and to the philosopher's stone."

It is difficult to say when chemistry—in the wider sense—was first practised in this country as a profession. It is certain

that in the early years of the nineteenth century such practitioners were in existence in different parts of the country, but, when the first Pharmacy Act was passed, in 1852, their number was very small compared with the number of pharmacists and druggists. Consulting practice in chemistry was often undertaken by the professors in the Universities, and teachers in technical insitutions; but already progress had been made in the teaching of science in schools, systematic courses in practical chemistry had been established in many places, and the number of chemists was steadily increasing.

The Chemical Society was founded in February, 1841, and the Pharmaceutical Society of Great Britain less than two months later. The Chemical Society, however, was not established as a professional body: its objects were then defined as "the promotion of chemistry and of those branches of science immediately connected with it, by the reading, discussion, and subsequent publication, of original communications," and seven years later, when it was granted a Royal Charter, as "the general advancement of chemical science, as intimately connected with the prosperity of the manufactures of the United Kingdom, many of which mainly depend on the application of chemical principles and discoveries for their beneficial development, and for a more extended and economical application of the industrial resources and sanatory condition of the community."

The Pharmaceutical Society received a Royal Charter in 1843, its objects including the advancement of chemistry and pharmacy, and the promotion of the education of those who should practise the same, as well as the protection of those who carry on the business of chemists and druggists.

The first Pharmacy Act, 1852, was passed "for regulating the qualifications of pharmaceutical chemists," but it did not restrict the practice of pharmacy or the sale of poisons. The Pharmacy Act, 1868, however, was passed "to regulate the sale of poisons and to amend the Pharmacy Act, 1852." The Pharmaceutical Society then acquired definite powers in respect of the qualifications of pharmaceutical chemists and the restriction of the sale of poisons to competent persons duly examined and registered by the Society. It will be found in the Pharmacy Act, 1868, that Section III distinctly defines the term *chemist and druggist* within the meaning of the Act, and the expression "within the meaning of the Act" is frequently inserted after the term "chemist and druggist." It was evidently considered necessary

to make quite clear that the Act was passed to regulate the sale of poisons, and referred only to those who sold and kept open shop for retailing, dispensing and compounding poisons. It was not intended to deprive persons who practised chemistry of the use of the term *chemist* which applied to them in a wider sense.

About seven years later—at the time of the passing of the Sale of Food and Drugs Act, 1875—the roll of the Chemical Society had grown to 801 members, and the number of consulting, technological, and analytical chemists had increased considerably. At this stage a movement was set on foot, mainly by younger Fellows of the Society, to make "F.C.S." a professional qualification by restricting its membership to those who had been systematically educated in chemistry and allied sciences. The Council of the Society being advised that the proposition was not within the powers of the Royal Charter of the Society and that the Society was not intended to confer a qualification, this movement eventually led to the foundation of the Institute of Chemistry, which occurred in 1877.

The aims of the Institute include the elevation of the profession of chemistry and the maintenance of the efficiency, integrity and usefulness of persons practising the same, by compelling the observance of strict rules of membership and by setting up a high standard of scientific and practical proficiency. Under the provisions of the Royal Charter of the Institute, which was conferred in 1885, it was granted definite authority to examine, to grant certificates of competency and to register persons qualified to practise the profession of chemistry in its application to legal investigations, to public health, to the detection of the adulteration of food and drugs, to agriculture, and to the arts and manufactures. These objects and duties have been steadily pursued for over sixty years. The roll of Fellows and Associates exceeds 7000, and the Institute enjoys to-day a high position among the professional chartered bodies in the country, both for the standard of its qualifications and the integrity of its members.

Early in 1879 the Council of the Institute had under consideration the question of the use of the title *chemist*, and addressed a communication to the Pharmaceutical Society, directing attention to the injustice to chemists who were not engaged in the practice or pharmacy, by the operation of Clauses I and XV of the Pharmacy Act, 1868—which might be construed as restricting the use of the title *chemist* unduly—and

urging that in any application to Parliament for an amended Act such an alteration might be made to remove the disability. The Council of the Pharmaceutical Society referred the matter to its General Purposes Committee, whose report contained a recommendation that the request of the Institute be acceded to when an opportunity arose. The report and recommendation were received and adopted.

In 1908, however, when further legislation was introduced, the Pharmaceutical Society was confronted with a different problem. While the law had reserved certain titles to registered individuals, this restriction had been held not to apply to public companies. The Poisons and Pharmacy Act of 1908 was passed, therefore, "to regulate the sale of certain poisonous substances and to amend the Pharmacy Acts"; and it gave power to a body corporate to carry on the business of a pharmaceutical chemist or chemists and druggist, provided that the business was under the control and management of a duly registered pharmaceutical chemist or chemist and druggist.

Clause 3 of Section III of the Act of 1908 gave to the chemist and druggist the right to make use of or exhibit the name or title of *pharmacist.*

The Institute of Chemistry has long held that pharmacists should relinquish the title of *chemist,* but is aware of the difficulties which exist in connection with this proposal.

These may be briefly summarised:—

(*a*) The right, conferred by the Act of 1908, of trading companies to the use of the word *chemist* (provided that a qualified pharmacist is in charge of every such business);

(*b*) The cost involved by making any sudden change, supposing the word *chemist* to be eliminated from all pharmaceutical and druggists' shops—by altering facias, labels, bottles, stationery, etc.; and

(*c*) The prevention of the adoption of the title *chemist* by drug storekeepers and other persons who are not qualified in accordance with the Pharmacy Acts.

It is felt, however, that these difficulties are not insurmountable, but might be overcome in time.

When fresh legislation—now the Pharmacy and Poisons Act, 1933—was under consideration, the Institute made representations the outcome of which, as is seen in the Act, was to entitle those who practise chemistry to call themselves chemists, provided that they did not sell goods by retail. This was a step in the right direction and should go some way to foster correct ideas, on the part of the general public, as to the use of the title *chemist.*

Chapter III

PROFESSIONAL EDUCATION

Before the general utilisation of steam power, the expression "technical education" had no reference to special training in science; it was used to denote the training in manual skill and in the use of tools in the practical arts acquired by artisans and operatives under apprenticeship. The superior skill of artisans and mechanics was then the predominant feature essential to industrial success, while, compared with modern standards, knowledge of the sciences was elementary. Science was regarded mainly as a pursuit for men of leisure. Chemistry was studied to a limited extent by medical and engineering students for the purposes of their vocations, but by comparatively few others; so that, apart from the professors in the Universities, there were few chemical practitioners. Technical schools and colleges, as we now use these terms, scarcely existed, and there were few laboratories for systematic practical instruction. Students were seldom afforded opportunities for individual practical work, but were taught by demonstration.

The progress made in the use of steam power—and, later, electrical power—in industries, as well as for locomotion, brought about great changes in international economic relations. Industrial conditions became changed in many ways, and the increasing application of scientific knowledge to industrial operations led to a demand for a new order of intelligence. To meet this demand, "technical education," with a new meaning, was introduced, so that the last ninety years have witnessed the establishment, throughout the country, of numerous institutions, the main object of which has been to provide practical and utilitarian, in addition to purely academical, instruction in the natural sciences. The Universities and University Colleges, while retaining their function of preserving and advancing pure science, also established faculties of applied science.

In the seventeenth century, Lord Bacon complained that the Universities were impeding the progress of knowledge. He contended that "in the Arts and Sciences, as in mines, all around

should echo with the sound of new works and further progress." The Universities have since made enormous advance: whereas in Bacon's time many objects then unattained were held to be impossible, it now appears to be clearly established that as more is achieved the possibilities of further achievement become greater—each succeeding generation building on the work of its predecessor.

During the past sixty years several colleges in our great cities have been constituted as universities, in which many of the students are to be found in the science faculties. Thus, University education has been made as readily available to those who lean towards scientific pursuits as to those who are devoted to literature and the arts. Situated in great manufacturing centres, they supply a real want. Endeavours have been made to meet the special requirements of such centres, and the interest of manufacturers has been secured by the election of men identified with industry as members of the governing bodies. Local industries have been stimulated and have materially benefited. The older universities and colleges also have rapidly developed their scientific departments to meet the needs of the times.

There are 19 Universities and over 200 Technical Colleges and other institutions in Great Britain and Ireland providing courses in chemistry and allied subjects; in all the Universities and in many of the Colleges courses are provided for the preparation of students for degrees in science. Provision has been made, therefore, for the professional education of chemists, of whom a constant supply is thereby rendered available for the service of the community.

The advance of chemical science depends upon all chemists, whether engaged as teachers, analysts, consultants, or technologists, and upon their fellow-workers in allied sciences. Credit for advances in theory and practice is due alike to teachers and practitioners. It is essential, therefore, that the closest relations should be fostered between all chemists for the furtherance of their science as well as for their educational and professional interests. Professors and lecturers are largely concerned with the promotion of research, by which constant progress is assured, and the chemist who is confronted with the problems occurring in practice can also take his part in education by indicating the trend of scientific application in industry and in everyday life.

A proper estimate of the education necessary for the profession can best be secured, therefore, by a body representative of all its various branches. This is one of the main advantages to be derived from an organisation such as the Institute of Chemistry, and its work in relation to the professional training of chemists will now be discussed.

The Regulations prescribed by the Institute, framed and developed by successive Councils consisting of both teachers and practitioners, represent an authoritative consensus of opinion on the system of technical education which provides a sound foundation on which the student can build his subsequent experience. The Institute has thus co-operated with the Universities and Colleges in promoting the extension and the steady improvement of the standard of education in chemical science.

The Regulations provide for the registration of students preparing for admission to the Associateship (A.I.C.). Such registration is not obligatory, but it is advantageous in that it brings the students at an early stage into touch with the work of the Institute. Through the *Journal and Proceedings* and through the lectures which are given before the Institute and published gratis to all members and students, they also learn something of matters of professional interest. It is advantageous, moreover, for the students to feel assured that, since the Regulations are liable to be changed from time to time, those who are duly registered can proceed to qualify for the Associateship under the conditions in operation at the time of their registration and can make arrangements accordingly.

The membership of the Institute (to which women are admissible as well as men) consists of Fellows and Associates. From the foundation of the Institute in 1877, a minimum of three years' systematic education at a recognised institution was prescribed as the main requirement of candidates for the Associateship (A.I.C.), although two years' experience under a Fellow in an approved laboratory could be reckoned in lieu of one year at an institution. In the course of time many of the recognised institutions became universities, and the majority of prospective chemists, on completing their courses, took degrees in science before qualifying for the Associateship. To-day, the ground to be covered has attained such dimensions

that, in spite of improvements in the methods of teaching and in the equipment of laboratories, *four* years is regarded as the minimum period for satisfactory preparation.

The main lines of the training required by the Council of the Institute are clearly stated in the Regulations, which can be obtained, gratis, from the Registrar; the details of the course must be left in the hands of the professors and teachers in the recognised universities and colleges.

With the increase in the number of technical institutions giving instruction in science, the Council of the Institute has had to meet the difficulty of deciding which should be placed on the list of those which are formally recognised for the education of candidates for the Associateship. Having in view the interests of the students, the Council has to be satisfied with regard to the general status of the institutions, the constitution of the teaching staffs, the syllabus of courses provided, the equipment of the chemical and physical laboratories, and the character of the work done by the students. The Council is thus able, from time to time, to add to the list of institutions formally recognised. For many years the problem was simplified by a regulation under which day classes only were accepted. Many technical schools providing only evening courses were thereby excluded from the recognised list. Training by evening classes was not, and still cannot be, regarded as entirely satisfactory, because it entails a heavy physical strain on the student who is also engaged throughout the day, but due provision is now made to enable evening students to qualify for the Associateship.

It will be observed, moreover, that a candidate whose courses have extended over at least *four* years, or the equivalent, who has passed the Final Examination for the degree of B.Sc. in chemistry in an approved University, is entitled to apply for admission to the Associateship Examination, provided he has had satisfactory experience and can satisfy the Council with regard to his training in Physics, Mathematics and an optional subject. To such candidates, therefore, no hardship arises from the fact that they have been trained in evening classes or at an institution which has not been formally recognised. The Council, in fact, has made special provision for candidates whose circumstances have prevented their following the normal curriculum and will consider an application for admission to the

Examination for the Associateship from any such candidate, provided (i) that he has passed an approved Preliminary Examination in subjects of general education or has otherwise satisfied the Council as to his general culture, (ii) that he has received systematic instruction satisfactory to the Council, by day or evening classes, in the prescribed subjects, and has passed approved examinations therein, (iii) that he has been engaged in the study and practice of chemistry for at least eight years, and (iv) that his case is recommended for special consideration by Fellows of the Institute who are personally acquainted with his work.

Provision has also been made whereby candidates who are not less than thirty years of age, and have had at least twelve years' approved experience and attained responsible positions may be admitted to a modified examination.

By accepting degrees as evidence of training and competence, the Institute has encouraged candidates to take full University courses, and to this, no doubt, is largely due the fact that over 80 per cent. of the Fellows and Associates are graduates. In the past the training for a degree in science was often academic rather than practical, and, therefore, conducive to the production of science teachers rather than of chemists qualified for other professional careers. Incidentally, the lack of suitable openings deprived them of opportunities of proving their ability in more practical directions. The Institute, however, endeavoured in its own examinations to promote the practical side of training, thereby setting a balance against the preponderance of theoretical instruction over laboratory work; so that in these circumstances a further course of practical training was often found advisable. Later, however, the character of the courses and examinations of the Universities became modified so as to render honours graduates in chemistry well prepared generally for the more directly practical branches of the profession. This has been recognised in the Regulations of the Institute.

A candidate who produces satisfactory evidence that he has complied with the following conditions is eligible to apply for admission to the Associateship without further examination by the Institute.

(*a*) That he has attained the age of twenty-one years;

(*b*) That he has completed a four years' systematic day course of study in the prescribed subjects—including chemistry

(inorganic, organic and physical), physics, mathematics, and one optional subject, at an institution recognised by the Council and has passed the appropriate examinations in the said subjects;

(Notes.—A candidate who has completed an equivalent course of evening study may apply for special consideration.

In lieu of one year of the course, the candidate may produce evidence of having complied with one of the following alternatives:—

(i) In lieu of the first year, two years' full-time study, including chemistry, physics, and mathematics, at a secondary school recognised by the Board of Education as efficient, or two years' experience in a laboratory under a Fellow—in either case after having passed an approved preliminary examination;

(ii) in lieu of the fourth year, one year's satisfactory experience under a Fellow or in a laboratory or works approved by the Council.)

(*c*) That he has obtained an approved degree with first- or second-class honours in Chemistry or a diploma recognised by the Council as the equivalent;

(*d*) That he is recommended by his professor of chemistry and, in appropriate cases, by the Fellow or head of the laboratory, or other responsible official, under whom he has been working during the fourth year.

Among the qualifications recognised by the Council of the Institute as equivalent to a degree with first- or second-class honours in chemistry are diplomas such as Associateship of the Royal College of Science, London, and the Associateships of the Royal Technical College, Glasgow, and Heriot-Watt College, Edinburgh.

It has been noted that in the colleges which provide a diploma course, students who wish to take the diploma are required to matriculate or to pass an entrance examination to the college, the object being to ascertain if the students have already acquired sufficient general education to enable them to proceed to more advanced work.

Technical education usually commences at about the age of seventeen. On admission to a college the student enters on a new phase of life, giving him greater freedom than he has enjoyed at school, but entailing greater responsibility and self-reliance.

The branches of science with which a chemist must be acquainted are so connected and so enlighten one another that it is impossible for him to attain a competent knowledge of any one branch, without an acquaintance with at least the fundamental principles of several allied branches. Though he has

comparative mastery over one branch, he will find the study of that obscure if he neglects others; and these, though subsidiary, should be pursued, all to such an extent that the knowledge acquired is real and useful.

The man with a smattering is found to be a source of danger in his profession. The trained technical man's bag of tools is his brain; the tools consist of the branches of knowledge he is able to exercise; the better he is able to use them by the aid of his "common sense," the more successful is he likely to be in practice; the broader his training, the better his equipment. With these considerations in view, there should be no question of avoiding the additional subjects. They are not prescribed merely to impose hardship on the student, but as a vital part of his preparation for professional life.

A student taking chemistry as his principal subject has usually evinced a liking for the science while at school, and shows in most instances considerable enthusiasm. His choice of chemistry as a career is deliberate—not a mere drifting into a profession. It is absolutely essential, however, that he should acquire the habit of *hard* and *purposeful* work. There should be no place in a college laboratory for those who do not, and it may be noted that laziness and dilatoriness are seldom chargeable to the evening class student with whom the more regularly trained graduate may sooner or later come into competition.

Chemistry is based upon experiment. A useful knowledge of the subject cannot be acquired from books alone. Without knowledge of the substances which he handles a student may carry out experiments to the danger of himself and of others; he may follow a book with some degree of safety and perform a series of operations limited by his resources in apparatus and materials. He will certainly learn something by his results and by his mistakes; but, with proper direction his progress will be much more speedy and effective.

The education of the student consists not merely in assimilating facts, the exercise of *memory* rather than *reason:* he has to be trained to *think*. He must acquire, determine and select the facts pertinent to any particular problem, and argue from them a logical, sound and useful conclusion. Chemistry particularly calls into use his natural faculties as well as his common sense. The faculty of observation should be cultivated in all practical work, as, for instance, in the recognition of substances

by their appearance and—with limitations—smell, taste and touch. The impressions gained thereby frequently assist in determining the course of an investigation. The aim of modern teaching is to produce thinkers, not mere accumulators of book knowledge; not mere testing machines, but men able to exercise their knowledge in scientific enquiry and to develop initiative and resourcefulness. The training must be clearly defined and efficiently carried out on broad lines, forming a sound basis for experience. The student must acquire some understanding of the character and effects of the more important chemical changes and processes in nature and the arts, in order that he may realise the relation of such changes and processes to basic principles, to each other and to the affairs of everyday life. His course should embrace the scientific study of typical technical processes on the large scale.

It is not sufficient to work through analytical tables and to repeat simple operations in qualitative and quantitative analysis. The student must be instructed systematically in the philosophy and history of chemistry and not simply learn, but understand; he must form a proper judgment upon the results of his work. The main objects of training, therefore, are (1) to induce in the student the habit of thought on general principles, in order that he may realise their practical bearing, (2) to enable him to carry out chemical operations with an intelligent appreciation of their meaning and purpose, and (3) to give him facility in expressing his results and conclusions in proper form.

The methodical keeping of records of practical work and the preparation of reports should form an important feature of the training. The records of practical work should be made at the time, omitting no essential detail, the results and conclusions being summarised in a concise and logical statement. Candidates presenting themselves for the examination for the Associateship of the Institute and, usually, those also who are taking university degree examinations, are expected to submit the actual notebooks used during the latter part of the university or college training for inspection by the examiners, who take them into account in adjudicating upon the examinations.

In addition to receiving systematic laboratory instruction, every candidate should be accustomed to use the microscope, spectroscope, colorimeter, refractometer, and other instruments commonly employed in chemical laboratories, and should also be able to draw diagrams of apparatus and instruments. The

acquisition of manual dexterity in the laboratory arts—glass-blowing and simple work in wood and metal—will prove of the greatest service to the chemist in his experimental work.

Reverting to the Regulations of the Institute, it should be specially noted that before presenting himself for the examination for the Associateship, the candidate, unless he has graduated or obtained a recognised diploma, is required to show that he has passed satisfactorily the class examinations of his college in each of the requisite subjects.

A chemist would be poorly equipped without systematic training in physics and mathematics. A knowledge of physics is most valuable to the chemist, particularly in industry, where many of the problems he will encounter are mainly, or wholly, of a physical nature. The minimum course in these subjects are of such a character that many students have already covered most of the ground at school. A working knowledge of the calculus, however, is desirable.

In the selection of an additional subject the student will be guided by its usefulness in the line of work to which he feels attracted. The industrial chemist should be a good physicist, and will find engineering a very useful subject. A chemist intending to practise in mineral chemistry will find it necessary to know something of mineralogy and geology; the prospective public analyst, something of physiology and botany; and the biochemist, something of biology and zoology. In fact, candidates who intend eventually to take Branch E, in the examination for the Fellowship of the Institute—The Chemistry (including Microscopy) of Food and Drugs, etc.,—will find it advisable to take a course in elementary botany, with practice in microscopy; and, similarly, candidates taking Branch D,—Biochemistry,—to take a course in elementary biology.

Promising students are frequently selected towards the end of their curricula to assist a professor in the conduct of research, which may be either of purely academic interest, or such as involves the application of knowledge and skill to directly practical purposes. Only the few who are naturally endowed with quite unusual skill and a very clear and logical habit of thought, equally unusual, can do valuable research without previous training. For most it is an invaluable experience to have the opportunity of working with a skilled and experienced investigator, of discussing problems with him, and assisting him

in carrying out his ideas and, in general, of coming under the immediate influence of a mind accustomed to the application of scholarship and logic to the devising, making and interpretation of experiments. If the student possesses any aptitude for research, any latent powers he may possess will be greatly developed by the chances offered him at this period. The universities have for many years required original research as a condition precedent to the granting of the higher academical qualifications, such as M.Sc., Ph.D. and D.Sc. At Oxford, candidates for the award of a "class" in the first Degree are required to submit an original thesis.

The chemist who finds this kind of work attractive may become a candidate for a Research Fellowship or Scholarship which will enable him to extend his experience, or he may obtain an appointment in a research laboratory connected with an industrial concern, or in a laboratory maintained by an industrial research association, of which about twenty-five have been established in co-operation with the Department of Scientific and Industrial Research; or he may become attached to the staff of an institution, such as the Imperial Institute, the Lister Institute, the Chemical Research Laboratory, the National Physical Laboratory, or an Agricultural Experimental Station; or take a position with a consulting chemist whose practice includes investigations bearing on industrial problems.

Good research chemists are comparatively rare. They vary from the straightforward thinkers, who achieve results by the laborious method of exhausting and eliminating one suggestion after another, to those whose mental activity is of such a character that they appear to seize upon the direct line of attack by some indefinable instinct or intuition. Others again have a greater faculty for directing than for carrying out the work themselves. They take time for reflection and by pertinent questioning and reasoning elucidate ideas of importance which might otherwise escape notice. Accurate analysts with manipulative skill are always desirable in the research laboratory. Indeed, the majority of chemical researches involve accurate analysis at some point or other, and frequently require the devising and testing of new methods of analysis to meet the exigencies of the particular case. Those who are skilled in laboratory crafts—first-rate glass workers or those handy with the ordinary tools of the carpenter, mechanic and plumber—are invaluable.

The experienced research chemist constantly notes problems for solution, determines the direction of a selected enquiry, and inspires his assistants with the train of thought underlying the scheme of operations. At some early stage in the enquiry (though preferably not before he has made some preliminary experiments embodying his new idea) he must acquaint himself with what has already been published on the subject. It is of great importance, therefore, that the chemist should acquire skill in searching and using the literature of chemistry, and should develop the ability to criticise and evaluate accurately what he may learn on any topic. He must, on the one hand, avoid wasting his time in rediscovering what is already known, and, on the other, not be deterred from valuable enquiry by an *appearance* of knowledge in the writings of others.

Often the discovery of new phenomena fails to find immediate practical application, but the importance of pioneer work is sooner or later recognised at its true value. For example, the experiment of the Rev. Dr. Clayton, Rector of Crofton, who distilled gas from coal amd collected it in a bladder, which Boyle showed to the Royal Society in 1688, may be regarded as the genesis of the gas industry which was established over 100 years later; Priestley's discovery of oxygen; Davy's experiments with nitrous oxide, and its subsequent uses as an anaesthetic in dentistry; the far-reaching effects of the investigation of the derivatives of benzene, which afford a striking illustration of the results of enquiry primarily conducted solely for scientific interest; the invention of the thermos flask by Dewar, for his experiments on liquefying gases, and its later general adoption for domestic use. When helium was isolated by Ramsay, it could hardly have been foretold that it would be used for filling dirigible airships, nor could it have been foreseen that neon gas would find extensive use in advertising signs. In the domain of physics, the whole of modern electrical power development has arisen directly from the discovery and exploration of electromagnetic induction by Michael Faraday.

The creation of the Department of Scientific and Industrial Research, the Government grants in aid of scientific investigation, the estabishment of research associations and other organisations in connection with various industries and the readiness of great corporations to finance pure research, have done much for the further encouragement of research chemists and the development of applied science.

The universities and colleges, realising that it is their business not only to educate, in the narrower sense of the word, but also to advance knowledge, have come to regard the prosecution of research as one of their most important functions. However, research is by no means confined to the universites and colleges; and it is not the practice to restrict the term to investigations in pure science. Teachers undoubtedly have the great advantage in research work that they are constantly reviewing the great and general principles, the full importance of which is always before them; and it would seem that the nearer discovery is related to such principles the wider are its ultimate applications. The science of chemistry has been considerably advanced, however, by the discovery of new analytical methods and the invention of new apparatus by consultants and analysts in practice; while applied chemistry has naturally been promoted in the main by chemists directly engaged in industry.

Comparatively few are able to occupy themselves in the pursuit of truth solely for the pleasure it affords and without reward; but we must be grateful that some such exist, and acknowledge that these chemist philosophers often produce remarkable results. Any chemist, however, may chance upon a great discovery. Really great and far-reaching discoveries cannot, in the nature of things, always be made by deliberate effort. The discoveries that matter most are often made by accident: all that is necessary (but it is a great deal) is that the man who happens, by chance, to *see* evidence of new phenomena shall also *perceive* it: that he shall be observant and enquiring enough to realise and search out what is under his hand.

Much has been said of the relation of research to invention, and it is not easy to determine where the one leaves off and the other begins; but it is interesting to note how they may follow one another in a cycle. An investigation of purely scientific interest may lead to the establishment of a new principle; next, to the invention of a new contrivance for the application of the principle, which in its turn may aid investigators in making a further discovery. Thus Newton, observing the production of a spectrum of colours by the passage of sunlight through a hole in a shutter and through a prism of glass, is the accredited discoverer of the principle underlying the spectroscope, which has become so important an instrument in many branches of scientific investigation. Many men before him may

have *seen* the same thing: he is honoured because he was the first to *perceive* it.

Few have the good fortune or the ability to initiate new theories or to bring forth epoch-making discoveries; but chemists need not be content merely to understand theories and facts as they are revealed to them. Success in scientific investigation, as in everything else, depends in the long run on the selection of the right persons to control and to carry out the work. The pursuit of industrial research demands not only a high standard of trained intelligence but practical acquaintance with methods and conditions of working on the large scale, such as are not ordinarily at the command of those who have not had experience in industry. At the same time, it must be remembered that industrial processes are no longer determined by purely empirical methods, but by the application of chemical and physical principles, and that a sound theoretical and laboratory training is the best foundation for work of that kind.

The institution of scholarships by County Councils, City Companies and private beneficence, has done much to bring students to certain colleges, though in may instances they are attracted by the high reputation of the professors, by the equipment of the laboratories, and by the facilities afforded for research. However, while the publication of researches by the teachers and students brings into prominence those institutions which produce men capable of conducting original investigation, the best gauge of their efficiency is their success in professional life. This must be held to apply to the general run of the students and not to a brilliant example here and there; for exceptional ability will assert itself even in the face of adverse circumstances.

One of the great advantages of university and college training lies in the influence which such training with its associations exercises on individual character. Personality of the right type is probably the most important possession of a professional man. It has sometimes been suggested that there is something in the study of chemistry inimical to the development of personality, and the chemist should, therefore, devote special effort to that development. During his student days he should endeavour to enter into all such activities as are calculated to induce "the team spirit," *esprit de corps*, and express in a practical fashion his loyalty to his university or college. The provision of students' unions and debating and scientific societies affords opportunities

for discussion among those preparing for the professions, and fosters self-reliance, which is a particularly valuable asset. Participation in debate and discussion helps a student to develop a critical faculty, and affords members of the teaching staff opportunities of forming opinions of the students' powers of exposition, which may later prove of assistance when recommending students for appointments. Many colleges possess chemical societies which arrange lectures, discussions and visits to works, and thereby encourage students to keep in touch with modern developments. Students should take every opportunity of learning something of the practical applications of their science, and those whose aim is to practise in industry are advised to devote particular attention to the study of physical chemistry, physics and mechanics. A later chapter is specially devoted to industrial chemistry.

The cost of training at the universities and colleges varies considerably. At some of the principal colleges in London the fees alone amount to as much as £60 per annum, but they are considerably less at others, and at certain provincial universities and colleges. Information on this point can be obtained directly from the secretaries or registrars of the respective institutions.

The Associateship (A.I.C.) Examination of the Institute of Chemistry, in General Chemistry, occupies at least five days, during which the examiners are at liberty to apply any test which they think desirable, either orally or by writing, or by experimental work, in order to obtain evidence of the candidates' knowledge of theoretical and practical chemistry. Candidates are required to answer papers on general chemistry (inorganic, organic and physical) and are examined orally during their practical work. They must be familiar with the use of such scientific instruments as are commonly employed in chemical laboratories, and with the principles underlying their construction. They are also required to translate technical literature from German and one other foreign language, with the aid of dictionaries.

Any candidate is at liberty to present a thesis or dissertation upon any chemical subject, to which he has given special attention, and the examiners will take it into account in arriving at their decision.

During the practical part of the examination, which occupies at least four days, candidates are at liberty to consult any books of reference which they may bring with them, or which

are in the Library of the Institute, or, in the case of a local examination, in the institution where the examination is held.

In common with other professional bodies, the Institute of Chemistry is concerned with the problem of supplying the demand of the public for evidence of competency. Those who are responsible for the conduct of the examinations are fully alive to the object in view, viz. to ascertain whether the candidates are likely to prove useful professional men. The A.I.C. examination fulfils that object. The Board of Examiners consists of representative teachers and practising chemists, and under the method adopted in conducting the examination, many of the drawbacks common to such tests are minimised. There is a sense of proportion in the relative standards required in the various parts of the examination, so that it constitutes a satisfactory test as a whole, and is of such character and scope that it tests real knowledge, rather than memory; ability and initiative, rather than an intimate acquaintance with text-book drill. Candidates are expected to give definite evidence of their usefulness for practical purposes: to show that they can carry out a reasonable amount of work accurately and in a reasonable period of time. The examination requires not merely an acquaintance with textbooks, but the possession of a thorough knowledge of chemical principles and a deal of common sense. It is a sound policy for the candidate, both in written and practical work, to make sure that what he does is done well, rather than to attempt too much and do it badly. Importance is attached to the manner in which the work is recorded; every step of consequence must be noted with all essential calculations.

It has been mentioned that candidates are allowed to consult books of reference during the practical work, and dictionaries when they are translating foreign technical literature; and, in general, it may be said that an endeavour is made to place them as nearly as possible under the ordinary conditions of practice; but collusion is strictly forbidden. The examiners are in personal touch with the candidates, and are thus the better able to arrive at a just decision in each case. Such a system gives the candidate a fair chance, eliminates the possibility of the incompetent passing, and frustrates the tendency to "cram." The examination is not in any sense competitive. Examinations are held in London three times annually; usually once a year in Manchester and Glasgow, and occasionally in other centres.

Examinations, in spite of their defects, have proved a valuable incentive to educational progress. At school and at the universities, some form of periodical examination is an aid in determining the fitness of the student to proceed to higher instruction. Examinations thus provide the student with a definite aim; the attainment of a higher standard; until eventually a standard is reached of such a character as to form a basis on which he may begin to build his experience. The passing of examinations, however, though it indicates enterprise and a determination to get on in the world, is obviously of less importance than the training it necessitates: the real value of the training is shown by the ability of the candidate to deal with the problems with which he is confronted, not only in the examinations, but in professional life, when he must learn to form his own opinions, rely on his own judgment, and acquire initiative in tackling questions, the answers to which are not always readily available in books. In a subsequent chapter it will be shown how he may derive considerable advantage by associating himself with societies devoted to his subject, which, by means of meetings for the reading of papers and by the publication of journals, disseminate useful knowledge, afford opportunities for mutual help, keep their members in touch with progress, and thereby widen the horizon of their respective spheres of work.

Apart from the satisfaction of passing the necessary examination, the successful candidate has the further satisfaction of knowing that he has attained a definite position in having acquired membership of a recognised professional body and that he can now take a part in promoting the general welfare of his calling. He should make it his business to advance the interests of his profession in any way that lies in his power, and particularly by maintaining a high standard in his professional work and conduct.

It is obvious from the foregoing considerations that facilities exist for the education of chemists capable of adapting themselves usefully to the needs of the community. The position of this product of the universities and colleges may now be considered. He has taken a degree or diploma and proceeds to seek an opening for a career, or, if means are available—perhaps by obtaining a scholarship—he will undergo special training for a higher degree, such as M.Sc. or Ph.D., in the hope of increasing his chances of making a good start. Possibly he may, for a

time, devote himself to research, or go abroad to gain the advantage of working under other teachers and to improve his acquaintance with foreign languages. He may specialise in a branch of technology, though in this case he should be careful to avoid losing touch with current work generally, or he may find that, when openings are not plentiful in the branch he has selected, he is not equipped for others. Provided that he does not lose touch with current work, a man with the research instinct should by no means be limited to the sphere in which he has had his original training, for he readily acquires the technique in other branches and, after a comparatively brief study of the subject, can successfully undertake research in another field.

Several universities and colleges have established courses in the applications of science to particular industries, and grant diplomas in various branches of technology. Thus, many students supplement their normal training by courses in technology in order that they may gain an insight into industries. Facilities are often afforded for students to visit, and in some few instances to work for a time in, certain works. Specialised training may be obtained in various institutions in different parts of the country, and the student has the choice of many subjects such as—Agricultural Chemistry; Bacteriology; Biochemistry; Brewing and Fermentation; Chemical Engineering; Fuel and Gas; Glass Technology; Leather and Tanning; Metallurgy; Oils, Fats, Soap; Paper-making; Photography; Physical and Electro-chemistry; Pottery and Ceramics; Sugar; Textiles; Rubber; and Tinctorial Chemistry.

With the progress made in thus developing our technical educational system, students can proceed from one institution to another in order to secure specialised instruction. Those who have taken such courses generally reap the benefit of doing so, and frequently increase their chances of finding appointments suitable to their attainments. The provision of these courses has encouraged the better equipment of students for taking part in the conduct of many processes on the large scale, by supplying them with much of the borderland knowledge between science and industry; though some manufacturers, who prefer to take a hand in shaping their chemists to their own liking, still hold the opinion that such knowledge can best be acquired by practical experience, and rely on the colleges to teach only what cannot be learned on the works. All are agreed, however, that a good all-round training is essential, so that the chemist may be more

generally adaptable, especially as the advance in industrial methods is so rapid that it is very difficult for the college courses to keep an even pace with modern progress.

Students intending to enter industrial work should, in any case, take advantage of every opportunity of seeing manufacturing operations, and of broadening their views on the applications of their science, which must remain somewhat narrow so long as their experience is restricted solely to the laboratory. They should endeavour to see something of metals in the working —with the use of furnaces, steam-hammers and rolls; of heavy chemicals—with the use of great stills, lead-lined tanks, iron evaporating pans, pressure eggs, stone filters, filter presses, and other appliances; of the manufacture of gas, and of many other important industrial products, with the method of handling them and the special plant employed. A good knowledge of pipe work generally is especially useful to the works chemist.

They should not neglect any opportunity of attending lectures by technical chemists of experience. Such lectures are given from time to time in the universities and colleges, in order to illustrate to students the difference between working with grams and with tons of material, and between working in glass beakers and in steel vessels.

Before passing to the consideration of the various branches of practice and the prospects they offer, mention should be made of the fact that Associates of the Institute who can show, to the satisfaction of the Council, that they have been continuously engaged in the study and practice of applied chemistry for three years since their admission, can proceed to the Fellowship. This they may do after passing a further examination, but those who have carried out original research, or devised processes or inventions, or otherwise satisfied the Council that they have fulfilled equivalent conditions, may in some cases secure election to the Fellowship without examination. It is rarely attained in this way, however, by Associates under thirty years of age. The Fellowship (F.I.C.), in any case, represents a minimum of seven years' systematic training and experience.

The experience necessary for the Fellowship can be obtained either by continuing to work in a university or college, or under a Fellow in private practice, or in the laboratory of a public authority, or in industry.

Normally each candidate for the examination for the Fellowship is required to select a branch, in which he desires to present

himself, such selection to be approved by the Council; but candidates whose experience is not covered by the syllabus of any branch specified may apply for permission to take a special examination. In these cases they may be required to attend before the Board of Examiners for a preliminary interview.

The Branches at present specified are:—A. Inorganic Chemistry; B. Physical Chemistry; C. Organic Chemistry; D. Biochemistry; E. The Chemistry (including Microscopy) of Food and Drugs, and of Water; F. Agricultural Chemistry; and G. Industrial Chemistry.

A candidate submitting himself for examination in any branch must satisfy the Council that he has had sufficient experience in the selected field of work. Thus, a candidate in Branch E must satisfy the Council that he has had at least three years' experience in work of the nature required.

The examination usually occupies six days; the syllabus of each Branch is given in the Regulations.

Chapter IV

PROSPECTS AND CONDITIONS OF PRACTICE

Becher, in his *Physica Subterranea* (1681), describes chemists as "a strange class of mortals impelled by an almost insane impulse to seek their pleasure among smoke and vapour, soot and flame, poison and poverty." The last word from the quotation will not appeal to the modern student of chemistry or to those who bear the expense of his education; but Becher is only one of many writers who have remarked on the poverty of the chemical philosophers of bygone times, and it cannot be said to-day that a scientific career provides a prospect of certain fortune. "Riches are not always to men of understanding, nor yet favour to men of skill; but time and chance happeneth to them all." (*Eccles.* ix. 11.) The same may be said of every profession.

Among the Greeks it was held that the standard of thought was lowered by attempting to turn scientific knowledge to practical ends,[1] and even now it may truly be said that some men of science pursue their investigations without sufficient thought of material gain. If, however, science were pursued solely as a means of gaining a livelihood, it would be no less an important manifestation of the progress of Man, the result of his inquisitiveness, and one of the highest forms of mental activity and achievement, since it conduces to the better realisation of his place in the universe. There can be nothing derogatory, however, in making a right use of knowledge gained,

[1] Bacon, who tells us that the true and legitimate goal of the sciences is none other than to endow human life with new discoveries and resources, protested against the view, held in his time, that the majesty of the human mind was impaired by long and frequent employment upon experiments. He also stated that Plato held that practice led men from the contemplation of truth and so degraded their intellect; and that Archimedes was half ashamed of his inventions.

"Archimedes regarded the engines of war which he invented not as being constructed by serious labour, but as the mere holiday sports of a geometrician, and although he acquired the glory of a more than human intellect he would not condescend to leave behind him any writings about his engines, regarding the whole business of mechanics and the useful arts as base and vulgar."—*Plutarch's Lives: Marcellus.*

and it is no longer supposed, as it was in the Middle Ages, that those who pursue science are only assisting the machinations of the Evil One. We look more and more to science to provide all that we require—our clothes, our food, and, indeed, everything that contributes to our comfort. Yet, even less than fifty years ago, there was pronounced opposition to the idea of creating a chemical profession; though it is interesting to remark that some of those who cried loudest against the pursuit of science for gain became, in the course of years, the most prominent in agitating for its fullest application in the affairs of everyday life.

It has been shown that chemistry is attracting an increasing number of well-trained and energetic workers who are alive to the fact that it is no longer solely an intellectual exercise. In this may be read a reversal of the dictum of Paracelsus: "The true use of chemistry is not to make gold but to prepare medicines." The business of the chemist with whom the Institute of Chemistry is concerned is not to make medicines, but to make gold,—or at least a livelihood for himself, perhaps wealth, for others—by the applications of his science to the affairs of everyday life. Generally speaking, however, few chemists appear to regard the matter only in that light: in general, at least at the commencement of their careers, they seek knowledge rather than affluence; but it is necessary and desirable that they should have regard to material rewards, for, like other people, they must maintain themselves, provide for the future, and bear in mind that the status of their profession depends, in the public estimation, to a large extent upon its remuneration.

The work of the chemist, in its character, its originality or otherwise, its scale of operations, and its responsibility, necessarily varies; but whether it be simple or complex, original or routine, on the laboratory or the works scale, merely of experimental interest or involving heavy financial or other responsibility, it should be carried out in a scientific spirit.

To be successful in almost any professional career a man must not only be properly qualified, but be known and esteemed among his brethren. His initiation into the practical business of life is commonly the result of the recommendation of someone who knows him and can speak well of his work, and his advancement depends largely on the repute in which he is held by his fellow-workers. The chemist, therefore, will be well advised to

join one or more of the recognised societies connected with his science, to which further reference will be made later. The choice will be determined to some extent by the nature of his work; but this should be the first step to be taken so soon as he has commenced to earn his living by his profession. If he is able to submit original papers and contribute usefully to the discussions held by these societies, he will be judged by his work and opinions; and, in the course of time, will find his place and become known among those who are active in furthering the common interests of his science and his profession.

It has been indicated that the middle of the nineteenth century was marked by an enthusiasm for science which led to the provision of increased educational facilities. Until "the seventies" there were very few institutions where practical chemistry was taught; and for practical physics there was scarcely a laboratory in the country until 1866, when Carey Foster established one at University College, London; though William Thomson—Lord Kelvin—had students working with him at an earlier date at Glasgow. Already, however, this country had produced some great chemists whose work will stand as records of progress. There were giants in those days, men of renown. There are giants in our time, and no doubt many not yet come to their full stature; but some of those who have long since established their positions are rather apt to overlook the fact that students of the present day, during their short training, have to cover the far wider field which has been explored and opened up during the intervening period.

A chemist may be engaged, either as a principal or as an assistant, in a variety of positions: (1) *in private practice*, which may be consulting and analytical practice, either general in character or with a marked bias towards some particular branch, such as, in the case of a public analyst, the chemistry of food and drugs, or in the case of an agricultural analyst, the chemistry of soils, fertilisers, feeding-stuffs, etc.; (2) *in industry*, either as a consulting technologist, practising independently, with a bias towards a particular industry or group of industries, or as a member of the staff of an industrial concern,—in the directorate or management, or in the control of a department, or as a research chemist or as an analyst; (3) *in a governmental or a municipal appointment*, in which the nature of the work may be general or specialised, and the duties may occupy whole or part time; (4) *in teaching*, which may be general or specialised

in the case of university or college appointments, but is usually *general* in school appointments, and, in the latter case, frequently associated with other science subjects; or (5) in a combination of two or more of the branches of work above indicated; or (6) in other employment in which his technical knowledge and ability are advantageous, though not necessarily the primary factors.

Special chapters follow relating to public analysts and official agricultural analysts, who are usually associated with the first branch indicated, and also to the industrial, governmental, and teaching branches.

To establish a consulting and analytical practice without any immediate clientèle requires financial resources and considerable patience. Success as a private practitioner can rarely be attained except by those who have served for some years either as assistants to established practitioners, or as chemists in industry, where they have acquired some reputation in particular fields of work. A sound knowledge of the main principles of their science is necessary to all chemists, yet some degree of specialisation is not only inevitable but desirable, since it is likely to afford opportunity for successful practice provided its applications are not too narrow.

On obtaining his first appointment in a commercial or industrial laboratory, the chemist, fresh from an academic atmosphere, finds that, in spite of his training and qualifications, his knowledge is, after all, still far from complete. He has acquired a knowledge of certain principles, but his training has not been so comprehensive as to enable him to deal with the many and varied problems submitted to him. He has only laid the foundation for experience.

The conditions are different from those of the college; he has to work much more rapidly and, perhaps, to conduct several analyses concurrently and accurately. He must acquire business habits and equip himself generally for professional life, in which there is much to learn which lies outside his college training. Take, for instance, the question of sampling, which is one of importance to chemists who undertake the examination of coal, ores, cement, fertilisers, oils, and other substances sold in large bulk. The results of analysis may affect considerable financial interests, with corresponding responsibility on the analyst. Substances are often sold on the basis of the figures reported by an analyst agreed upon by the parties to a contract;

or each such party may appoint a chemist, and agree upon an independent practitioner to arbitrate in the event of discrepancy in results, which may arise owing to differences in sample, or in the analytical methods employed. It is often advisable, therefore, that the actual samples and the methods of analysis should be agreed upon before examination. The sampler may be experienced in the particular trade concerned, independent of buyer and seller, or the chemist himself may be reponsible for taking samples. He should, in any case, be acquainted with the recognised methods of sampling, which sometimes entail considerable knowledge, as in the case of coal. Again, some substances vary under changing conditions of temperature, or it may happen that a portion drawn from the top of a cask or drum may be very different from that taken from the bottom. Sampling in prospecting for minerals or oil also requires technical experience. In the examination of water, too, it is necessary that the chemist should be fully acquainted with the source of supply and the general surroundings, in order that he may arrive at sound opinions and advise accordingly.

Again, the form of report to be adopted in different cases is also a matter of importance both in connection with official work under statutes, and in general practice. Further reference will be made to certificates when matters of professional procedure are considered.

Many statutes are of importance to chemists, such as the Alkali, etc. (Works) Regulation Act, 1906; Fertilisers and Feeding Stuffs Act, 1926; Gas Undertakings Acts, 1920–1934; Margarine Act, Metropolis Water Act, 1902; Petroleum Acts, 1926 and 1928; Pharmacy and Poisons Act, 1933; Rivers Pollution Prevention Act; and the Food and Drugs (Adulteration) Act, 1928.

The chemist should make himself familiar with the main provisions of those statutes which may affect the branch of work in which he is likely to become engaged. A comprehensive list of statutes and regulations is given in an Appendix to "A List of Official Chemical Appointments"—Ninth edition (1937), published by the Institute of Chemistry.

It is advisable that he should also be informed with regard to the law relating to licences for stills, although the Board of Inland Revenue allows professors and teachers of chemistry and analytical chemists who carry on no business involving the manufacture of any article for sale from, or containing spirit, to

use a still or stills in the *bona fide* exercise of their profession without taking out a licence. What constitutes a "still" within the meaning of the Act has not been specifically defined, but any apparatus capable of being used for the distillation of liquids is liable to licence duty, and, excepting under the conditions above mentioned, the keeping of a still without licence is an offence, no matter for what purpose it may be kept. Persons who desire to obtain exemption from licence duty must make application to the Board of Inland Revenue, such application being made usually through the local supervisor of Inland Revenue.

In some laboratories the recovery of spirit is a matter of much economic importance. The Board of Inland Revenue reserves the right to insist, in every case in which it appears necessary in the interests of the Revenue, on a strict observance of the regulations, but has no desire to exercise that right in such a manner as to interfere unduly with the ordinary practice of an analytical and consulting chemist. The Board, however, requests that formal application be made by chemists who desire to recover or purify methylated spirit.

To resume the consideration of the conditions of practice, a wider outlook in chemical work may be expected in the future. Analysis is, and is likely to remain, the foundation stone of chemical practice, but the work of the chemist now demands initiative and resource often of a very high order for the solution of practical problems of great variety. It should not be supposed that analysis consists only in routine testing. With a widespread use of chemistry in industries, analytical problems of great complexity are frequently encountered in the examination of new products and the exploration of new methods. For this kind of work the chemist must not lose hold of his knowledge of inorganic and organic chemistry, and must keep ever in mind the principles of chemical structure and the properties of the substances with which he is dealing.

When gas-lighting was a novelty, those who understood it could command a good fee for superintending gas-fitting; similarly, with the installation of electric bells, and later with electric lighting. With the progress of science these and many other services of scientific origin have become things of everyday account, valued less as they become more ordinary. Some acquaintance with the principles of analysis is becoming a part of every boy's education, but the *chemist* must be more than

an analyst. If a junior has had experience in research at college, he may be given opportunities of working on industrial problems and, if successful, his principal may be able to recommend him for a post in industry. If he has worked with a public analyst or an official agricultural analyst he will have acquired the experience necessary for obtaining the qualifications demanded for certain official analytical appointments and may thus secure a nucleus for establishing an independent practice.

The chemist who does not need immediately to earn his living may with advantage devote himself independently to research on industrial problems, but can rarely do this unless he has obtained some inside experience of industry. This branch of work has been known to lead to very profitable results, from investigations directed to devising processes which have been patented. In such cases the chemist needs the assistance of a trustworthy patent agent who is well qualified to act in chemical matters. On the other hand, he may sometimes prefer, or find it advisable, to put his invention into operation independently.

In chemistry, as in other professions, there is always scope for the best. Broadly speaking, professional success is achieved by *competence*, based on a sound general education, systematic technical training, and close acquaintance with modern practice, *capability*—the skill to apply knowledge and experience—and *individuality*, which comprises trustworthiness, tact, energy, enthusiasm, foresight, and general force of character. The result lies almost entirely with the individual. In any case, he cannot expect to command success without merit, patience, and persistent hard work.

The discipline of the technical training, the mental exercise involved and the social advantages of his college life all tend to render the chemist a useful man. Occasionally he will turn to a career in which his science is directly useful, though it may not be the actual basis of his business. Thus, a few chemists have qualified for the Bar, practising in cases connected with technological matters, patents, etc.; others have become patent agents, or educational inspectors, or mining prospectors, or scientific journalists, or have secured commercial positions in industries on which chemistry has a bearing. The chemist seldom, however, entirely relinquishes his profession: change of career becomes more difficult as time passes, and, in general, it is

found that the older a man becomes, the less likely is he to succeed by making a change.

The possession of financial resources may occasionally enable a chemist to purchase an interest in a practice or in an industrial undertaking, or may warrant him in waiting for an opportunity of securing an appointment suited to his inclinations, whereas his less fortunate brethren must perforce take what they can get. During the first year of experience—particularly if he has no independent financial resources—he should carefully consider whether his position affords a prospect of advancement. If not, he will be wise to look to his own interests, or he may become so devoted to the interests of those with whom he is associated and so engrossed in his work as to overlook the fact that he has his own career to make.

Every man can strive to get himself out of the ordinary rut and can do his best to attain, if not a controlling position, at least one in which he can exercise initiative and find opportunities for relying on his own resources. If he does not have regard to the future and neglects to improve his position he will find himself falling behind, and sooner or later blame himself, or more probably the profession he has chosen, for the fact that many suitable appointments in his particular branch are not available to men of his age and experience, unless they have acquired an exceptional reputation.

Complaints that the profession is unremunerative are generally raised by those who have neglected their own interests while they were still young. It serves no purpose for a professional man to feel aggrieved that he earns less than a workman; or that a man in trade "makes" as much in a few minutes as he (the professional man) does in as many years. He may reasonably hope to leave the workman far behind; but he must bestir himself if he wants to get on in the world, and so long as it is in his power to effect an improvement in his position he should not despair. Although nearly 14 per cent. of the members of the Institute are engaged in the Overseas Dominions or elsewhere abroad, there is sometimes a difficulty in placing well-qualified men because they will not venture away from home, or do not want to follow a particular branch of work, or are in some way particular as to the disposition of their services. Those who are devoid of enterprise do not usually make leaders of men or contribute to the advance of industries or to the progress of nations.

The success of every profession depends mainly on the individual efforts of its members. The aim of the individual, therefore, should be to acquire knowledge, skill, and experience of the highest order, so that he may render himself available for suitable opportunities as they arise; and be ready and willing to venture when the time comes. Comparatively few professional men get rich quickly: the majority work many more hours a week than any craftsman, and yet few earn anything approaching what they deserve until they have obtained considerable practical experience; but the chemist has a chance as good as, if not better than, many other professional men to give evidence of his worth: his field of work is so wide. However, it must be deplored that chemistry has not yet acquired that material recognition which is its due. It is only by united effort in educating public opinion that its claims will be brought home to the uninitiated.

The chemist, in that he chooses his profession deliberately and because he likes it, is to be envied; but he is to be pitied if he is subsequently confined to routine work, without opportunities of developing new ideas or solving new problems.

The poor remuneration of industrial chemists in the past was due, in many cases, to the fact that the work on which many of them were engaged consisted largely of routine analysis which could be carried out sufficiently well by youths who had had a short training in a limited variety of analytical processes and who were willing to accept positions affording them experience. An analyst in charge of a fairly large laboratory may occupy a reasonably remunerated position; but for routine laboratory work there is a limited value. The well-trained man should soon be able to secure a position commensurate with his attainments.

It is often very necessary to remind the chemist that his sphere need not be restricted to the operations of the laboratory. If it should be his ambition to occupy a controlling position in industry, he should lose no opportunity of becoming acquainted with processes on the manufacturing scale. When he finds his outlook restricted to routine work, with no opportunity for developing ideas of his own, and no prospect of going on the works, he is well justified in seeking another appointment.

There have been frequent complaints with regard to the salaries of chemists in whole-time official appointments. Such complaints are by no means confined to those holding chemical

appointments: ministers of religion, lawyers, medical men, schoolmasters, architects, accountants, engineers—in fact, all classes of professional men, are at one time or another invited to become candidates for appointments offered on inadequate terms and unsatisfactory conditions. In the long run such matters are adjusted by the law of supply and demand. Many considerations, however, may enter into the question whether candidates will be willing to apply for a position; the nature of the duties and the responsibilities involved; whether previous experience is expected; what advantages in the way of experience or prospects are attached to the appointment; whether it carries a pension; whether the holder is free to undertake practice independently in his spare time; whether the individual concerned is so modest in his requirements as to consider his labour a hobby, or perhaps a duty to the State and not merely the means of earning a livelihood, and so forth.

Is it too much to hope that no author of the future will have cause to write in the strain of John Ruskin in *Sesame and Lilies?*

"I say we have despised science. 'What,' you exclaim, 'are we not foremost in all discovery, and is not the whole world giddy by reason, or unreason, of our inventions?' Yes; but do you suppose that is national work? That work is all done in spite of the nation; by private people's zeal and money. We are glad enough, indeed, to make our profit of science; we snap up anything in the way of a scientific bone that has meat on it, eagerly enough; but if the scientific man comes for a bone or a crust to us, that is another story."

Long after Ruskin wrote that (1864), a chemist without previous experience, but with good qualifications, could only with great difficulty obtain an appointment at all. Frequently a practising consultant would take into his laboratory a newly-qualified man at a nominal remuneration, as a pupil-assistant, in order to give him an opportunity of gaining experience. To obtain an appointment at £100 a year was regarded as a fairly good start and many were obliged to accept less. As the demand for chemists increased or showed signs of gaining on the supply, the position was improved.

In the profession of chemistry, there is not and cannot be "a minimum wage" acceptable generally to men of such varied attainments; but in some public departments definite scales of salary are in operation, having due regard to the education, training, qualifications and experience of the chemist, as well as the character, importance and responsibility of the work entrusted

to him. Yet, with all these circumstances to be taken into consideration, the matter becomes complicated. The broad principle of making the practice of chemistry attractive to a due proportion of the possessors of the best brains in the country must not be ignored, while it must be remembered that, in the main, chemists are more directly concerned with production than other professional men.

On the other hand, the matter may be approached from the point of view of the employers, who get, in the long run, what they pay for. If they offer a small salary, they receive a corresponding selection of candidates to choose from and must either take whomever may be available or improve the terms; but if they are inclined to be liberal, they will get a good selection of candidates with the prospect of obtaining results out of all proportion profitable compared with the increased expenditure involved. At the present time many companies prefer not to offer a junior chemist without previous experience less than £250 a year; others place the minimum at £300 a year. If the candidates are not deemed worthy of the suggested salary, they are not engaged, or if they fall short of the expectations of their employers their services are dispensed with, or they remain in junior positions; if they are worth more, a definite contract is offered for a term of years on an agreed basis. If manufacturers generally adopted such a plan, the chemists would know what to expect and there would be less cause for complaint. The amounts indicated above do not represent the value of services rendered by the chemist, but rather the initial salary which the companies are prepared to pay him. When he has acquired experience in their industry and proved the value of his services, his position should be correspondingly improved.

In a contract of service, it is very advisable that the chemist, even though he may be appointed assistant manager, or manager, should also be acknowledged and described as a *chemist*. The contract should specify a period of time; the salary—say "a monthly salary at the rate of £— per annum, or such further sum as the employer may from time to time direct"—; the place; the duties, defined as broadly as may be convenient; hours of duty; and holidays. The contract should provide for the payment of expenses incurred in the business or on behalf of the employer. The secrets of the employer must be safeguarded, and the chemist may be required to agree that any improvement, invention or discovery which he may make shall be the property

of the employer. A reasonable period and area of restraint may be prescribed during and in which the chemist may not, without the written consent of the employer, enter the employment of or be associated with, any business similar to, or in competition with that of the employer. In such cases, the employer should agree to pay the chemist a proportion of the salary during such period as the restraint may be exercised. Provision may also be made for the continuance of salary of the chemist during a reasonable period of illness, before his appointment be terminated on account of absence. It is common practice to require that notice of 90 days shall be given (in writing) by either side to terminate the appointment.

In industrial posts, conditions are likely to improve because the control in a measure is passing gradually, but surely, to men of science; but where this is not so, the outlook will be promising from the chemists' point of view only where the principals concerned are properly appreciative of the importance of science and are able to judge of the qualifications requisite for the appointments under their control.

It is to be hoped that in the course of time the profession of chemistry in all its branches will be accorded more and more the position and emoluments which are its due as one of the liberal professions, on whose knowledge modern civilisation relies in times of peace and whose power is indispensable for national defence.

Appointments Register.

The Institute of Chemistry maintains a register of Fellows and Associates who are available for appointments and notifies them of suitable vacancies. Several universities and colleges do the same for their graduates. Public authorities and firms increasingly look to the Institute, as well as to the universities, to assist them in securing the services of well-trained chemists; many are thus introduced to their first appointments or are enabled to improve their positions. The Honorary Corresponding Secretaries of the Institute, in Overseas Dominions, assist in this as in other branches of the work of the Institute.

A candidate for an appointment is advised to make a concise statement, including the following particulars, and obtain a number of neat copies of it:—Name, address, age, degrees and qualifications, education, training, experience, if any, and

references. In answering advertisements he should send a copy of the statement with a covering letter neatly written on good paper, carefully expressed, directing attention to his special qualifications for the position offered, and enclosing, when asked for, copies of testimonials. Many people prefer to act as references rather than to give testimonials, and this is often the more satisfactory method of obtaining reliable evidence.

Chapter V

PROFESSIONAL ORGANISATION

Every profession and calling derives benefit from the existence of a representative body established to define a standard of qualification for practice and to act in the interest of its members; indeed, a profession, in the sense of a collective body engaged in a specific calling, can hardly be said to exist until a representative organisation has been established. Such organisations are expected to maintain the efficiency and professional integrity of their members and a sense of fellowship and mutual responsibility among them. Membership is sought, therefore, as much from a desire to assist in maintaining the prestige of the profession or calling and to support its work, as for any personal benefit that may accrue to the individual member.

The earliest records of professional organisation in this country relate to the schools of law, which were in existence in the thirteenth century; those relating to medicine date from the fourteenth. Most of the other representative professional bodies—representing architects, engineers (civil, mechanical, and electrical), accountants and actuaries, chemists, surveyors, journalists, patent agents, secretaries, and so forth—have come into existence since the early part of the nineteenth century.

In all professions there is frequent agitation for more complete organisation, with a view to the improvement of the status of their practitioners. On the other hand, the tendency to specialise in some particular branch of work inevitably leads to cleavage. Sooner or later, other bodies are formed working separately, yet with similar, though more specialised, aims. One of the objects of such bodies is to provide registers of competent men for the service of the community, but none of these bodies, except those relating to the law, medicine and pharmacy,—and, recently, dentistry and architecture—has acquired statutory powers of compulsory registration, and there is diversity of opinion, in some instances, as to the desirability of their doing so. In general, great advantage has resulted, however, from the existence of such bodies, and the principal professional societies and institutions have been officially recognised by incorporation under Royal Charter. They exist for the public good as well as for that

of their members; while they acquire rights and privileges, they acknowledge mutual obligations in the relations of their members to one another as well as to the community.

In aiming at the enhancement of status, there is constant desire for improvement in matters educational, technical and ethical. It is not reasonable to expect that these matters can ever be definitely established for all time or to the satisfaction of everybody; but, under the influence of these movements, there is a general tendency towards higher standards and higher ideals.

Just as there are many different types of men who style themselves "engineers," so that are also many who adopt the title "chemist." Many enter on their professional careers well educated and thoroughly trained, but others offer their services with far less qualification, or make their first practical acquaintance with the application of science as laboratory attendants or "testers," who are engaged in routine analysis in works or possibly in private laboratories during the day, supplementing this experience by attending evening classes at local technical schools.

As has been said already, the profession comprises chemists in practice as consultants, chemists engaged in industry, public analysts, agricultural chemists, chemists in Government service, and professors and teachers of chemistry. There are also chemical engineers, metallurgists, and other chemical advisers, with special experience in one or more branches of technology. Some, again, combine two or more of these departments of work. All these may legitimately style themselves "chemists"—whether engaged in analysis or synthesis or in advising on the elucidation of technical problems, perhaps involving considerable financial outlay, or holding appointments as professors in universities, teachers in technical schools, or science masters in secondary schools,—provided that they are properly trained and competent.

The status of chemists differs widely, but there should be scope for the humblest assistant to improve his position; and, indeed, many who have started as laboratory assistants have attained very good positions, some in practice independently, others in industry, others in Government employ, and so forth.

To effect the *complete* solidarity of persons, so diversely qualified and engaged in such a variety of ways under one organisation and for all purposes, appears to be impracticable: in most professions there is one organisation for the registration of

qualified practitioners, and various societies to bring together those interested in various branches of work. If any attempt were made to classify them in groups according to ability, it would be found that whereas some have general knowledge and skill of a high order, but are not specially expert in any one particular branch, others have highly specialised knowledge of perhaps a limited sphere of work, and are lacking in knowledge of some of the fundamental principles of their science. There is scope for those who are competent to undertake only routine testing as well as for those who are thoroughly equipped for higher analytical and research work, or for the control of operations in industry, or the conduct of professional practice as consultants.

From time to time it has been suggested that there should be legislative restriction on the practice of chemistry. Statutory registration in any case does not prevent anyone from giving advice; it may prevent the unregistered from recovering fees in court and assist the public to discern who are competent. The Institute of Chemistry, as the chartered professional qualifying body, serves the latter purpose. It appears doubtful, however, whether general support would be forthcoming to any measure for the restriction of chemical practice, except in matters affecting the health and well-being of the community, as in the case of public analysts and official agricultural analysts and of chemists engaged in dangerous industries, for which special skill and experience are requisite.

The latter half of the nineteenth century witnessed the foundation of many societies and institutions for the promotion of the study and practical application of different branches of science. Their continued vigorous existence is a proof of their utility, while their work has undoubtedly exercised a stimulating influence on the growth of knowledge during the same period. From small beginnings they have become a great power by promoting the efficiency of their members, by disseminating useful knowledge, establishing facts and exposing errors, and by bringing scientific and practical men into close association to their mutual advantage.

The Societies and Institutions interested more or less directly in the advancement of chemical science include (1) bodies aiming at the promotion of all natural science, and (2) those concerned with chemistry in particular, either in its purely scientific or in its professional and more utilitarian aspects.

In the first category there are—the Royal Society of London, the parent society of the scientific bodies in this country, founded in 1660; the Royal Dublin Society, in 1731; the (Royal) Society of Arts, in 1754; the Manchester Literary and Philosophical Society, in 1781; the Royal Society of Edinburgh, in 1783; the Royal Institution of Great Britain, in 1800; the Royal Philosophical Society of Glasgow, in 1802, and the British Association for the Advancement of Science, in 1831.

In the second category are—the Chemical Society, founded in 1841 and incorporated by Royal Charter in 1848; the Institute of Chemistry, founded in 1877 and incorporated by Royal Charter in 1885; the Society of Chemical Industry, founded in 1881 and incorporated by Royal Charter in 1907; the Society of Public Analysts and other Analytical Chemists, founded in 1874 and incorporated in 1907; the British Association of Chemists, originally established in 1917; and the Institution of Chemical Engineers, incorporated in 1922.

The main function of the Chemical Society—whose Fellows number about 3,800—is to foster original research in Chemstry and to facilitate the discussion and dissemination of new knowledge in all branches of the science.

Fellowship of the Chemical Society is open to men and women of all nationalities who are interested in Chemistry and wish to keep in touch with its advances. Fellows are elected by the Council. A candidate for Fellowship is required to produce a certificate signed by not less than three Fellows of the Society to whom he is known personally. In the case of a candidate resident abroad, the Council is empowered to accept a certificate signed from personal knowledge by one or two Fellows of the Society.

The Journal of the Chemical Society, which is published monthly, contains the results of investigations covering the whole field of pure chemistry extending to its common boundaries with physics, geology and the biological sciences. At present about 450–500 papers are published annually in the Journal.

The Society collaborates with the Society of Chemical Industry, the Physiological Society, and the Biochemical Society in maintaining the Bureau of Chemical and Physiological Abstracts, which issues every month British Chemical and Physiological Abstracts. These consist of abstracts of papers dealing with all branches of pure and applied chemistry and physiology, published in all parts of the world. British Chemical and

Physiological Abstracts "A" is divided into three sections:—A (I), General, Physical and Inorganic Chemistry; A (II), Organic Chemistry; A (III), Physiology and Biochemistry.

The Society also publishes the Annual Reports on the Progress of Chemistry. These reports, written by specialists, summarise the important advances in pure chemistry and related subjects which have recently occurred and afford a comprehensive and stimulating survey of the development of the subject.

The Library of the Chemical Society is available to members of other Societies which contribute to its maintenance. Its 41,000 volumes deal fully with every aspect of Chemistry and with many branches of related sciences. Some 900 volumes are added annually.

Ordinary Scientific Meetings of the Society are held in London on the first and third Thursdays of each month from October to June at Burlington House, when papers dealing with original work are read and discussed. Organised discussions—usually four each year—on subjects of current chemical interest are arranged, and lectures by eminent British or foreign Chemists are delivered annually. Meetings for the reading of papers, lectures and discussions are also held outside London and form an important part of the activities of the Society in the provinces.

The Research Fund is available for the assistance of chemical research, and sums amounting annually to about £600 are granted for this purpose.

Fellows who pay the annual subscription of £3 have the following privileges: To receive free of charge the Journal of the Chemical Society and either British Chemical and Physiological Abstracts "A" or the Annual Reports on the Progress of Chemistry; to consult, and to borrow in person or by post, the books in the Library; to attend all meetings, lectures and discussions organised by the Society in London or in any other centre in England or Scotland, and to introduce two guests; to apply for research grants; to submit original papers for publication in the Journal.

Fellows under the age of 25 have the option of paying half the annual subscription and receiving, until the end of the year in which they reach that age, the Annual Reports on the Progress of Chemistry, and either the Journal of the Chemical Society or British Chemical and Physiological Abstracts "A."

The Institute of Chemistry of Great Britain and Ireland, which registers over 7,000 Fellows and Associates and about 800

Students, aims at the maintenance of the status and efficiency of the profession of chemistry, by promoting the better education of persons desiring to follow that profession; by setting up a high standard of scientific and practical proficiency; by the examination of candidates and the registration of such as have been found to be competent; and by insisting upon the observance of strict rules with regard to professional conduct. The Regulations with regard to the training and examinations required for the qualifications for Membership—A.I.C. and F.I.C.—have already been reviewed in the chapter relating to professional education. Lectures are given before the Institute and its Local Sections on matters of professional and scientific interest. The Institute possesses a useful Reference Library, open to Fellows, Associates and Registered Students, primarily intended for the use of candidates during the practical examinations. Members and students also have the privilege of using the libraries of the Chemical Society and the Science Library, Science Museum, South Kensington. An Appointments Register for the benefit of members who are seeking appointments is kept at the Offices of the Institute, and a Benevolent Fund is administered for the benefit of necessitous members and their dependents. The Institute also maintains a List of Laboratory Assistants who have passed approved Preliminary Examinations and are available for junior vacancies.

The *Journal and Proceedings* is published in six parts annually, and contains particulars of the work of the Council, abstracts of the reports of the Examiners, reports of meetings, etc.

Twenty-two Local Sections have been formed to maintain the interests of Members in matters of professional importance and to promote social intercourse:—Aberdeen and North of Scotland, Birmingham and Midlands, Bristol and South-Western Counties, Cape of Good Hope, Cardiff and District, East Anglia, East Midlands, Edinburgh and East of Scotland, Glasgow and West of Scotland, Huddersfield, India, Ireland (Belfast), Ireland (Dublin), Leeds Area, Liverpool and North-Western, London and South-Eastern Counties, Malaya, Manchester and District, Newcastle-upon-Tyne and North-East Coast, New Zealand, South Wales (Swansea), and South Yorkshire.

In co-operation with the Board of Education in England and Wales, with the Scottish Educational Department, and with the Ministry of Education for Northern Ireland, the Institute awards "National Certificates in Chemistry" to part-time students.

These Certificates are accepted for some junior grade appointments in Government and industrial laboratories, and their attainment affords a "stepping-stone" towards the Associateship of the Institute. (Students' Annual Registration Fee: 10s. Associateship Examination: £5 5s. Fellowship Examination, for Associates: £5 5s.; other candidates: £10 10s. Annual Subscription: Fellows, £2 2s.; and Associates, £1 11s. 6d. Entrance Fee to Associateship: £2 2s. (Students registered two years: £1 1s.); Entrance fee to Fellowship: £5 5s.; for Associates elected after 1st March, 1922: £2 2s.; for the Fellowship without Examination, an additional non-returnable Fee of £5 5s. is payable.)

The Society of Chemical Industry numbers about 4,000 members. Its principal objects are to advance applied chemistry and chemical engineering in all branches; to afford its members opportunities for the interchange of ideas with respect to improvements in the various chemical industries, and for the discussion of all matters bearing upon the application of chemical science; and to publish information thereupon. Local Sections of the Society have been formed as follows:—American, Birmingham, Bristol, Canadian Pacific, Edinburgh, Glasgow, Liverpool, London, Manchester, Montreal, Newcastle-upon-Tyne, Nottingham, Ottawa, Shawinigan Falls, South Wales, Sydney (N.S.W.), Toronto and Yorkshire.

Subject groups deal respectively with Chemical Engineering, Food, Plastics, and Road and Building Materials. Panels are formed for promoting progress in the science of Microbiology and Nutrition. The monthly Journal (*J. Soc. Chem. Ind.*) includes Transactions and British Chemical and Physiological Abstracts "B". The weekly Journal is entitled *Chemistry and Industry* and deals primarily with current and forthcoming events, contributed articles, reviews, reports of meetings of sections and groups and of other bodies, with summaries of papers and full text of lectures and addresses. Both journals are issued free to members. (Entrance Fee, temporarily suspended: Subscription, £2 10s.; Life Composition, according to age and period of membership.)

The Society of Public Analysts and other Analytical Chemists numbers about 800 members. The objects of the Society are to cultivate the study of analytical chemistry, by holding periodical meetings, and by the publication of a journal devoted mainly to analytical chemistry; to study questions relating to the adulteration of articles of food, drugs, and commercial products

generally, and means for its detection; and to promote the efficiency and proper administration of the laws relating to the repression of adulteration. The Society co-operates with the Institute of Chemistry in matters of professional interest to public analysts and official agricultural analysts. Every candidate for membership must be twenty-one years of age, be, or have been, engaged in analytical, consulting, or professorial chemistry, and be recommended by three members, who shall provide written testimony of their personal knowledge as to his scientific and social fitness. The recommendation is read at an Ordinary Meeting and is printed in the notice convening the next Ordinary Meeting, at which election is decided by ballot. *The Analyst,* the official organ of the Society, is issued monthly, and contains reports of the proceedings of the Society, the papers read at its meetings, abstracts, information as to analytical methods, legal notes, reviews, etc. (Entrance Fee, £1 1s.; Subscription, £1 1s.)

The object of the Institution of Chemical Engineers (founded 1922) is to act as a professional and qualifying body in relation to the practice of chemical engineering. Monthly meetings are held from October to April, and the Annual Meeting is held in July. The papers submitted and discussed are published in the *Transactions.* (Entrance Fees: Members, £5 5s.; Associate Members, £3 3s.; Graduates, £1 1s.; Students, 10s. 6d. Annual Subscriptions:—United Kingdom: Members, £5 5s.; Associate Members, £3 3s.; Graduates, £2 2s.; Abroad: Members, £3 3s.; Associate Members, £2 2s.; Graduates, £1 11s. 6d. Life Composition, according to age. Students, under 21: 10s. 6d., over 21: £1 1s.)

Other bodies interested in chemistry have been formed from time to time, some for local purposes, social and professional, and others with different aims. There have been movements towards the organisation of associations for the promotion of the economic interests of chemists, e.g. to endeavour to secure for them more adequate salaries, and to provide unemployment benefits. The difficulty of dealing with the rate of remuneration of chemists arises largely from the greatly varying limits of capability and the variety of the tasks alloted to them. Scientific work can hardly be remunerated on the same principles as are the mechanical crafts. A "flat rate" would in any case be unfair to those who are more capable and more energetic, while few qualified chemists, even among those engaged in

work of a routine character, would care to admit that they should be entitled only to the minimum rate: there will always be some more capable than others, most reliable, quicker in their work and keener in their science. This is equally true of other skilled workers, but it is difficult to imagine chemical practice being subject to control, as to time and output, on the lines of the usual trade union system, and not many of those who hope eventually to attain positions of responsibility in their profession could for long be content to submit to any system tending to restrict initiative and ambition. The chemist who really cares about his science is not likely to leave an experiment for the reason that he has completed so many hours work in a day; though, of course, there should be mutual understanding—some idea of "give and take"—between him and his principals. An educated and properly trained man should be able to establish his claim to the proper recognition of his services: reasonable employers are not likely to overlook men of decided promise, and such men would be usually well advised to secure positions elsewhere if they find that their services are not fully appreciated.

The British Association of Chemists was established to give practical expression to the view that there should be an organisation to represent the "economic interests" of chemists. Its objects include—the attainment of adequate recognition for chemists in the practice of their profession, the establishment of a scale of minimum salaries, the restriction of practice of chemistry to properly qualified chemists (the term "chemist" to be legally re-defined), the maintenance of an appointments bureau, and the provision of legal aid and unemployment benefits. The Association publishes *The Chemical Practitioner*. (Annual Subscription: Members, £2 11s.; Probationers, 10s. 6d.; Students, 5s.)

Thus, for practical purposes, chemists are organised by these Societies, each having its particular work.

The suggestion has often been made that the chemical interests of the nation should be further concentrated. A Federal Council of Chemical Societies was constituted, in 1920, for the promotion of the interests of pure and applied chemistry. This Council was formed to ensure the adequate appreciation of the claims of chemical science, to consider matters involving the common interests of its constituent bodies; to take appropriate action in connection therewith, after consultation with any bodies

concerned or identified with the matters under consideration; and to consider such references as it might from time to time receive from its constituent bodies, or otherwise, and, if desirable act thereon. The Federal Council, which has now ceased to exist, represented British Chemistry at Conferences of the Union Internationale de Chimie and at the International Congresses of Pure and Applied Chemistry. The British National Committee for Chemistry of the Royal Society now ensures the representation of organisations concerned with pure and applied chemistry, at such meetings. The Federal Council also dealt with such subjects as atomic weights and chemical nomenclature and, finally, promoted negotiations with a view to bringing about closer co-operation between the three Chartered organisations,—The Chemical Society, The Institute of Chemistry, and the Society of Chemical Industry.

In 1935, these three Bodies subscribed to a Deed of Agreement for the formation of a Chemical Council, on which industry also is represented by delegates from the Association of British Chemical Manufacturers, to raise and administer a fund to assist in meeting the cost of chemical publications and the Chemical Library. The Chemical Council determines the allocation of grants for the co-ordination of scientific and educational publications, for the publication of new discoveries, for the promotion of research, and for the maintenance of the Library of the Chemical Society.

Chemistry is above all a progressive science. When the chemist has passed his examinations and secured his qualification for practice, he must endeavour to keep pace with the progress of his science and with its applications to-day, and have regard to its possible applications in the future; and since he cannot afford to neglect opportunities of extending his knowledge and gaining experience, he finds it advisable to keep in touch with his professional brethren by joining one or more of the chemical societies. Yet, if he would maintain broad views, he should associate frequently with those who follow other lines of thought and take part occasionally in activities outside the scope of his immediate circle.

In addition to those already mentioned, there are societies and institutions which include professional chemists who are interested in the special industries or subjects with which the institutions are concerned.

	Founded
Biochemical Society	1911
Ceramic Society	1900
Faraday Society	1903
Institute of Brewing	1886
Institute of Fuel	1927
Institute of Metals	1908. Inc. 1910
Institute of the Plastics Industry	1931
Institution of Chemical Engineers	1922
Institution of Gas Engineers	1863
Institution of Mining and Metallurgy	1892. Inc. 1915
Institution of Petroleum Technologists	1913
Institution of the Rubber Industry	1921
International Society of Leather Trades Chemists	1897
Iron and Steel Institute	1869. Charter 1899
Microchemical Club	1934
Oil and Colour Chemists' Association	1918
Society of Dyers and Colourists	1884
Society of Glass Technology	1916
Society of Public Analysts and other Analytical Chemists	1874. Inc. 1907
Society for the Study of Alchemy and Early Chemistry	1936

Such bodies encourage research and discovery and, by their meetings and publications, assist chemists to keep in touch with modern developments and progress.

Such bodies afford their members facilities for bringing practical discoveries under the scrutiny of their brethren and others likely to be interested. Some seek to establish new knowledge, others to apply it to practical purposes. New views and ideas are evolved from collective reasoning and debate, and the subject may be still further advanced by open criticism and friendly rivalry. The publication of research and invention affords a chemist legitimate means of acquiring status and reputation. He need not be content to remain always a spectator; if he is able to advance his science, he deserves well of his fellows, and becomes known by his work. Thus, the publications of the societies contribute to the vast storehouse of knowledge and constitute the record of the progress of science.

In addition to the Journals and publications issued by the British Societies and publishers, many useful journals are published by American, German, and other foreign Societies which should not be neglected, and the student will do well to peruse regularly at least one journal devoted to matters of general scientific interest.

Libraries, too, are essential to the chemist who would endeavour to keep pace with his subject. Besides the fine library of the Chemical Society and the reference library of the Institute, mention should be made of the Patent Office Library, and of the Science Library (South Kensington), which contain comprehensive collections of scientific works of reference.

Chapter VI

PUBLIC ANALYSTS AND OFFICIAL AGRICULTURAL ANALYSTS

Among the officials in the courts of princes in medieval times, not the least important were the tasters, whose duty it was to ensure that no poison or other injurious matter was introduced into the food of their lords. In like manner, ale-tasters or ale-conners, were appointed by municipal bodies, to look to the goodness of ale and to inspect the measures used in taverns. The liverymen of the City of London, in Common Hall, on Midsummer's Day each year, appointed such an officer; and history relates that Shakespeare's father held such a post at Stratford-on-Avon. It is said that one of the methods of tasting —or rather testing—was to pour some ale on a Windsor chair in which the officer, garbed in buckskin breeches, seated himself: if the breeches adhered firmly, it was supposed that sugar had been added.

In the sixteenth century authority was given to physicians to examine the preparations of apothecaries and druggists, and with the progress of time, the testing of both foods and drugs has become an important branch of chemical science and practice, affecting intimately the welfare of the public in both health and pocket.

The first volume of the Proceedings of the Society of Public Analysts, published in 1876, indicates how the investigations of Dr. Hassall and other chemists were instrumental in directing the attention of Parliament, in 1860, to the question of checking adulteration of food. Legislation was demanded for the protection of the consumer without placing unfair restrictions on the producer. The first Adulteration Act, passed in that year, was practically inoperative; and the second, passed in 1872, though an improvement on the first, was not satisfactory in administration. That it was only partially enforced was due largely to the scarcity of analysts available for carrying out its provisions, but also to the fact that it had been drafted in such a manner as to perplex magistrates, whose decisions on the prosecutions coming before them were frequently at variance.

The introduction of these Acts appeared to the traders at the time as a vexatious interference with their liberties; but it was in reality contributory to their well-being, in that such legislation protected honest vendors from nefarious competition, apart from the more important consideration of the public benefit. This form of legislation, however, was greatly resented by tradesmen, and the general public appeared to be then much in sympathy with their grievances. The defects in the Act of 1872 soon came into prominence and, two years later, a Select Committee of the House of Commons was appointed to enquire into the working of the measure. Numerous witnesses were examined and a Report was published, which in addition to suggesting the probability of further legislation, impressed the Public Analysts then in office with the desirability of forming an Association. The foundation of the Society of Public Analysts was decided upon at a meeting held on the 7th of August, 1874, and at the first general meeting, held four months later, the Society arrived at a definition of "an adulterated article." From that time the Society has carefully watched the introduction of fresh legislation, and has encouraged amongst its members the mutual interchange of opinions on methods of analysis and on the interpretation of results, particularly in connection with the examination of articles of food and drink. In 1907, the name of the Society was extended to—"The Society of Public Analysts and Other Analytical Chemists."

After the new Bill had been printed and circulated, the Society devoted itself to securing the modification or removal of objectionable clauses, its suggestions being considered while the Bill was in Committee. The Society received support from the public and the Press, put itself in communication with the Local Government Board, and forwarded a schedule of suggested amendments, which, with few exceptions, the President of the Board readily approved; so that the Bill was much improved before proceeding to the House of Lords. Considerable support was also obtained in the House of Commons, notably due to a speech delivered, on the second reading of the Bill, by Dr. Lyon —later Lord—Playfair; but opposing influences were also exercised, and the Society was then confronted with criticism, both in the House of Commons and in the Press, especially with regard to the competence and integrity of public analysts. The reference of disputed analyses to the "Somerset House" Laboratory, at that time a department of the Board of Inland Revenue, was

regarded as an injustice to analysts of standing, and, when it was suggested that "Somerset House" decisions should be considered *final*, the Society entered a strong protest, recommending that, in cases of prosecution, whoever made an examination of a reference sample should be required to testify to his analysis on oath, since the reputation of a public analyst might otherwise be at the mercy of a Government subordinate who might be of no greater competence. It was ascertained subsequently that the intention of the Government was to make both equally liable to give the figures of analysis on oath and to be subject to cross-examination. The Press commented on differences in analytical results, almost invariably casting discredit on the public analysts concerned. In some cases samples taken under the Act were known to have been deliberately tampered with. The Society, therefore, gave careful consideration to the methods of taking, dividing and sealing samples, and its recommendations on this part of the Bill were subsequently incorporated in the Act. Owing to the intervention of the Society, the Bill in its later stages was so entirely different from the original as to render it practically a new Bill; and, although, when the Act was eventually passed, it contained provisions of which the Society did not approve entirely, it could not on the whole be regarded as a bad compromise, and was a much more satisfactory and comprehensive measure than either of those it repealed.

The subsequent working of the Act showed that some of the objections raised by the Society were not altogether well founded. For instance, in the matter of taking samples, there appears to have been a suggestion that collusion was likely to occur between unscrupulous vendors and inspectors, which has only rarely been found to exist in practice and, again, the system of referring samples to "Somerset House" (now the Government Laboratory) in cases of dispute has not proved an unsatisfactory arrangement or revealed a great amount of discrepancy in results. When differences arise they are frequently easily explainable. For example—it is not unlikely in the case of certain substances, such as milk and butter, that the sample, of which the public analyst receives only one-third, may not have been uniformly mixed.

The relations between public analysts and the Government Laboratory are reciprocally cordial. Such relations are ensured so long as a high standard of training and qualification is insisted

upon on the part both of the chemists of the Government Laboratory and of the public analysts, and provided there continues to be a mutual interchange of opinion on methods of analysis and like matters.

Prior to the passing of the Act of 1875, the appointment of public analysts by local authorities was permissive and not compulsory, except at the request of the Local Government Board.[1] The local authorities in many cases had ignored the earlier Acts: twenty-seven counties neglected to appoint public analysts, and these only gradually fell into line under the encouragement of the Local Government Board. Where the Acts were not enforced, adulteration continued prevalent: of samples taken in various parts of the country, the percentage of those found to be adulterated varied from seven to forty-eight; yet wholesale traders indignantly denied the prevalence of adulteration, while they protested strongly against giving warranties of purity or guaranteeing retailers against loss incurred by prosecutions under the Act.

The number of competent analysts available being very limited, and no standard of qualification being recognised, appointments were made which had subsequently to be revoked. Some who might reasonably have claimed to be analysts had no special experience of the work which they were called upon to do. In a few instances, medical men, with practically no knowledge of analytical chemistry, were appointed, and some of them endeavoured to "farm out" their analytical work; where incompetent men were entrusted with the duties, the reputation of the profession was considerably damaged owing to their mistakes. However, in the course of time they were removed and the few who were recognised as competent received further appointments.

Under the stress of competition in trade, and with the gradually increasing restrictions on adulteration, the artifices adopted to evade the law became more subtle. To combat such sophistication the necessity arose for more definite evidence of competency on the part of candidates for appointment as public analysts. Up to that time, no definite endeavour had been made to organise the profession of chemistry. The need for some authority to test the competency of those who wished to practise in this branch was one of the main factors leading to the foundation of the Institute of Chemistry.

[1] Now the Ministry of Health.

The public analysts became an organised branch of public service. Candidates for appointment were required to possess "competent knowledge, skill, and experience," and the Local Government Boards, to whom such appointments were referred for approval and confirmation, were empowered, before giving such approval, to require the production of satisfactory proof of competency. The Select Committee of the House of Commons on Food Products Adulteration (1894) reported, however, that the method of testing the qualifications of candidates was not wholly successful and suggested that the production of a recognised diploma or certificate should be required. The Council of the Institute, therefore, established a special examination in the Chemistry (and Microscopy) of Food and Drugs, which was duly approved by the Local Government Boards as qualifying candidates for these appointments, with the result that the public analysts to-day form a body of highly skilled and competent chemists who have rendered excellent service to the community, while they have in no small degree advanced the science and practice of analytical chemistry.

It was anticipated that many samples for analysis (under the Act) would be submitted by private persons, but this has not proved to be the case. The mention in the Act (1875) of a fee of ten shillings and sixpence for the examination of such samples is greatly to be deplored, since that sum cannot be regarded as a standard. The debate in the House of Commons, when the Bill was under discussion, clearly indicated that such a fee was insufficient, and should be augmented from the rates. An average fee of ten shillings and sixpence leaves no margin of profit when all working expenses have been taken into account. Many investigations cannot be conducted at such a fee by any professional chemist making a reasonable charge for his time, leaving out of the question the cost of his training, the upkeep of his laboratory and the value of his experience and opinion. The public analyst is in most cases obliged to regard his appointment as a whole, accepting an average fee for samples of all kinds. If the samples submitted included a preponderance of those requiring difficult and complex analysis, he could not hold appointment at the fees now commonly paid. For this reason it is well that water was not included in the Act, though Public Analysts are usually entrusted with its analysis. The appointments have been held in many cases mainly as a nucleus for practice and possibly to attract to the holders a proportion of

the private consulting work, not necessarily connected with food and drugs, arising from the industries and commerce of the counties or boroughs for which the public analysts are appointed. The Adulteration Acts have been considerably extended and many regulations have been introduced tending to increase the duties and responsibilities of these public officers. Moreover, the public analysts themselves have so much advanced the science of their branch of work as to render it often necessary for them to conduct—with increased expenditure of time and money—a far more exhaustive examination of the articles submitted to them than was formerly regarded as sufficient, or even possible, until new methods had been devised.

These matters, however, are little understood by the local authorities, who often fail to appreciate the nature and value of the services of the analyst, and have in some instances shown a tendency to reduce rather than increase the fees allowed for analyses, in spite of the fact that the expenses of living have advanced and the remuneration of other citizens in practically every walk of life has steadily risen. Apathy and lack of appreciation will tend in the course of time to counteract the desire of trained chemists to undertake public work of this character, except as whole-time officers working under authorities who bear all the expenses of laboratory maintenance, which is a far more costly scheme for the ratepayer.

The Ministry of Health, which is charged with the administration of the Acts, persistently declines to intervene in the question of remuneration, and it is unlikely that anything short of an Act of Parliament stipulating the payment of adequate fees will put the matter on a proper basis.

When appointments of Public Analysts have been offered at inadequate salaries, the Councils of the Institute of Chemistry and the Society of Public Analysts and other Analytical Chemists have advised chemists to refrain from becoming candidates for them. The Institute has endeavoured to fulfil the duty imposed by its Charter of providing the community with a body of highly competent chemists for the public service, and has provided the State with the recognised means of ascertaining those who are qualified for these appointments. It is felt, therefore, that the Institute has a right to expect in return that the services of highly trained and qualified professional men should be rewarded in a manner consistent with the nature of their work and the responsibility of the public duties with which they are entrusted. The

aim of the administration should be to secure efficient service. The remuneration and conditions of these public appointments should, therefore, be such as will promote efficiency with integrity.

The question has been frequently debated as to whether the object of the legislation for the suppression of adulteration is directed to the punishment of fraud or the maintenance of the public health. Whereas it was stated in the preamble to the Act of 1872 that "the practice of adulterating articles of food and drink for sale in fraud of Her Majesty's subjects, and to the great hurt of their health and danger of their lives, requires to be repressed," and the preamble to the 1860 Act was very similar, the Act of 1875 merely stated that it was desirable that those Acts should be repealed and the law requiring the sale of food and drugs in a pure and genuine condition should be amended. Thus the preamble of the Act of 1875 ignored equally any explicit reference to fraud or health, but it is clear that it is intended both to prevent fraud and to safeguard the food of the community and insure the genuineness of drugs.

In France a similar statute is regarded as mainly directed against fraud, but it includes provisions in the interests of health; in Belgium, legislation is directed against adulteration with noxious substances; in Italy, Switzerland, and Germany, the chief object of legislation in these matters appears to be to prevent the sale of unsound or injurious food by imposing penalties for fraud and ignorance, carelessness, or negligence in manufacture. In Germany, however, the restrictions do not apply to substances intended for export.

Since profit is commonly the object of adulteration, the question of fraud should certainly weigh in the judgment of such matters, and the penalties imposed should be a real check to the fraudulent trader.

In the early days of this legislation local authorities occasionally appointed their Medical Officers of Health as Public Analysts. While there were not sufficient professional chemists for the work, there was some justification for this procedure where the medical officer was competent to undertake the work—but this was very rarely the case. Very few medical men possess a competent knowledge in any branch of chemistry. The smattering of chemistry required in the ordinary medical curriculum and for the Diploma in Public Health is totally inadequate for the practice of chemistry. The public analyst and the medical

officers are drawn from two distinct professions; their duties are distinct in their nature and require an entirely different training.

Under the Act of 1875, provision is made for the taking of samples by Medical Officers, sanitary inspectors and police, so that local authorities have commonly entrusted the supervision of this duty to the medical officers; but since the Act declares that those who take the samples are to submit them to the public analyst, if they suspect the same to have been sold contrary to the Act, it was clearly not the intention that such officers should also act as public analysts. Moreover, there is no indication that it was intended to place the public analyst in a position in any way inferior to that of the medical officer of health, who is not required by any statute to take any further part in the administration of the Adulteration Acts. Though the Medical Officer may be asked to report on domestic water supplies, he will be wise to refer such matters to a qualified chemist.

The most ingenious defences are devised to evade the penalties prescribed by the Act on purely technical grounds. One of the chief of these was in connection with section 25[1] of the Act, under which the defendant retailer may rely on a written warranty received at the time he purchased the substance, to relieve him of the responsibilities which he may incur if it should be sold contrary to the Act. In the Act of 1875, food was defined as every article used for food or drink by man other than drugs or water; but it is significant that the word *adulteration* was not defined.

The Public Analyst must be acquainted with the statutes and regulations under which he performs his duties, but is in no sense a public prosecutor. He has to examine to the best of his knowledge and ability any sample of food or drug submitted to him and to report whether or not it is of the nature, substance, and quality demanded. He is required to state his opinion on the genuineness of the sample and to specify the percentages of any foreign ingredient present. In the case of drugs, the courts have construed adulteration as "impurity" if the sample has been sold in such a state "as to affect injuriously the quality or potency of such drug."

It was at one time not infrequently advanced by the defence in cases of prosecution that the public preferred certain admixtures in articles of food which come within the meaning of the Acts. Thus, for instance, the public might show a preference with

[1] Section 29 of the present Act.

regard to the colour of a substance—such as butter or milk—and the dealer would endeavour by the use of colouring matters —such as annatto—to meet this fancy.

A number of articles such as cheese, whiskey, and brandy appear to need definition. The employment of brandy and whiskey as alcoholic stimulants in medical treatment illustrates the importance of such definition. The analyst must decide how far the purchaser has obtained what he had a right to expect, which for lack of standards is often difficult to determine.

In 1905, the Local Government Board for England and Wales (now the Ministry of Health) established the Department of Inspector of Foods, the staff including both medical men and chemists, whose duties have embraced scientific investigation, reports on which have been published from time to time. The Department has given particular attention, *inter alia*, to preventing the importation of diseased meat in various forms, of unwholesome canned foods and of other unsound articles of food and drink.

Under Section I of the Public Health (Regulations as to Food) Act, 1907, the Local Government Board—now the Ministry of Health—is empowered to make regulations authorising measures to be taken for the prevention of danger arising to the public health from the importation, preparation, storage, and distribution of articles of food intended for sale for human consumption. The Ministry has framed many such regulations and has issued numerous circulars of instructions to local authorities.

The main statute at the present time is the Food and Drugs (Adulteration) Act, 1928, which repealed much of the earlier legislation. (A new Bill will probably be introduced into Parliament in the near future.)

The Annual Reports of the Ministry on the working of the Acts, have shown that special attention has been paid to dairy products, the prevalence of adulteration indicating that the penalties imposed have been usually too lenient. A supply of pure milk is essential owing to its importance as an article of food, particularly for infants and invalids. On account of the varying quality of milk under different conditions, there has been a laxity in adjudicating cases with strict regard to the standards prescribed. The prevention of tuberculosis, diphtheria, and similar diseases being one of the main objects, the public analyst is at a great advantage if he is qualified to undertake the bacteriological examination of samples. Greater

attention is now given to the cleanliness of cows, sheds, utensils, and milkers; and greater precautions are taken against contamination by dust, during transit, in shops and in the houses of the consumers; but much remains to be done to ensure a wholesome supply of a substance so liable to contamination. One disadvantage of fixing standards for milk is that the fraudulent trader may be enabled to lower its quality to the limit at which prosecution may be avoided. The resources of science can be applied to adulteration as well as to its detection. The purity and soundness of food should be protected both in the factory and in the shop.

In the production of butter, various substitutes have been employed which defy detection except by the most experienced analysts.

Regulations issued within recent times make it compulsory for the analyst to ascertain the absence of any preservative in samples of food, or to detect and estimate any preservatives which may be found in them; also to determine within close limits preservatives which may be found in the scheduled articles, to identify scheduled colouring matters in food, and detect and estimate thickeners in cream.

The administration of the Acts also calls for the employment of chemists, not necessarily public analysts, for the defence of vendors in cases which come into court; and many manufacturers and traders engage chemists either on their staffs or as consultants, to keep a check on their products and merchandise and to advise them as to standards and so forth. It should be mentioned, however, that in the event of legal proceedings, while such chemists are required to support their findings personally, the certificate of a public analyst is accepted as evidence without his attendance at court, though he may be required to attend for cross-examination by the defence.

The public analyst who makes a mistake suffers in prestige. In the law, judges occasionally express the opinion that the litigants have been badly advised: for instance, that a case should not have come into court. That is a matter between solicitor and client. In medicine, eminent physicians may make a faulty diagnosis, and scarcely anyone hear of it. In architecture, mistakes can often be rectified before the building is completed. The public analyst, however, whose practice as such consists largely of investigations bringing usually but a small return, is answerable as a public official, and his reputation

is at stake on any lapse from accuracy, though it may be the result of an accident—for instance, through a confusion of samples, or lack of uniformity of composition of a sample which has been unevenly mixed.

It has been suggested that the promoters of this legislation "had their tongues in their cheeks" when they entrusted its administration to the Borough and County Councils, seeing that it is directed in the main against the possible dishonesty or carelessness of tradesmen, who are usually well represented on such bodies. The Acts were and still are administered very unevenly. In many prosecutions offences are regarded lightly by the magistrates, who, for serious impositions on the public, inflict trivial fines, representing but a small fraction of the ill-gotten gains made by fraudulent traders. The Acts still need a far more rigid enforcement, more samples should be examined, and the penalties for infringement greatly increased, where deliberate fraud is proved, before a pure supply of food can be ensured.

In the Alkali, etc., Works Regulation Act and the Factory Act, the administration lies with the central authority, and it has often been debated whether the same system should not apply in the administration of the statutes against adulteration. Formerly, the constituent members of local authorities had no knowledge of the training and experience necessary for the proper conduct of professional chemical practice; they did not understand the nature of the analysts' duties; but there are signs of a better appreciation of these matters since the regulations as to competency of public analysts were framed. The standard of competency is now well defined, the Ministry accepting, as sufficient documentary evidence of the requisite qualification, the Fellowship or Associateship of the Institute of Chemistry, together with the certificate granted by the Institute after an examination conducted by them on lines approved by the Ministry.

The public analyst, whether engaged as a whole-time or part-time officer, is frequently expected to act in a consultative capacity to his local authority. He may thus be requested to make analyses of water, sewage, sewage effluents, etc., and to examine, or advise on, cement, paint and many other materials, or to assist in drawing up specifications for supplies. He may act as gas examiner under the provisions of the Gas Undertakings

Act, 1920–1934. Occasionally, too, he is required to investigate cases of suspected poisoning, involving the examination of viscera, both human and animal.

He may also be required to make analyses for the police authorities in connection with counterfeiting coins and other crimes. Moreover, he may act as a consultant to manufacturers of all kinds of food, such as flour, bread, biscuits, chocolate, milk preparations, margarine, preserved meats and fruits, pickles, jams, etc. Thus, the work coming to a public analyst covers a very wide sphere, and not only requires knowledge, skill and experience, but frequently entails heavy responsibility.

Public analysts, too, are often qualified for holding appointments as official agricultural analysts, in which capacity they examine samples taken under the Fertilisers and Feeding Stuffs Act. Those who specialise in agricultural analysis also analyse and advise upon soils, and conduct other investigations for agriculturists.

The first Fertilisers and Feeding Stuffs Act was passed in 1893 and was amended in 1906. The Fertilisers and Feeding Stuffs Act, 1926, has since come into force, together with Regulations issued in 1928 and 1932.

Notwithstanding the importance of science, and particularly of chemistry, in the cultivation of the land and the feeding of cattle, agricultural chemistry can scarcely be regarded as providing much scope for practice except as an adjunct to other professional work. The competition of public institutions renders it of small advantage for chemists to engage in this branch, unless they hold appointments in the Agricultural Colleges or Research Stations, or are retained by one or more of the well-known agricultural societies and can establish a connection with large commercial concerns manufacturing or importing fertilisers and feeding stuffs. Yet there is hardly an industry which owes more to the chemist than agriculture. As the source of food and, to a large extent, of textile products and of other necessaries of life, agriculture, of all industries, demands the closest attention of men of science. The application of chemistry and bacteriology to the treatment of soils has vastly improved the output and quality of all agricultural products. As the crops exhaust the life-maintaining constituents of the soil, means must be found for restoring such constituents, or the soil becomes barren. The introduction of chemical fertilisers is the outcome of scientific discovery; the continued satisfactory production of such substances depends largely on the supply of competent chemists.

Chapter VII

INDUSTRIAL CHEMISTRY

The successors of the alchemists in the eighteenth century for the most part regarded the study of chemistry as a pastime or an intellectual exercise; its connection with industry was little appreciated, and few workers in science pursued their experiments with any idea of their possible application to industries. The proprietors of works were mainly commercial men relying on foremen more or less acquainted with the operations involved, but possessing themselves little knowledge of the principles on which such operations were based. The processes adopted were commonly founded on empiricism, or accumulated experience, handed down from generation to generation. Much importance was attached to processes being kept secret: sometimes it happened that the secret was lost through the death of a partner or trusted foreman; more often the "secret" was the common property of the industry. There *are* secrets, however, and many are kept for long years; so that the most recent technological literature published may contain all but what people are most anxious to know. In the course of time, the employment of trained men of science led to the discovery of the secrets or of better methods which speedily effected changes in the direction of improvement; but even then the chemist was not infrequently denied the run of the works lest he should learn too much. Later, as the advance of his science elucidated manufacturing problems and he became more closely connected with the large-scale operations, he was not infrequently at a disadvantage through lack of engineering knowledge.

The invention of a process is not complete until the plant for it has proved efficient on the manufacturing scale. The designer must possess both chemical and engineering knowledge and skill, and thus, even where the chemical character of the processes predominates, the chemist who is not equipped for such work may find himself occupying a comparatively subordinate position.

In the increasing application of science to industrial development the co-operation of the profession of chemistry is of primary importance; in fact, chemists are attached to almost every productive industry. The following list, mainly selected

from the schedule adopted by the British Bureau of Chemical Abstracts, affords some idea of the range of industries with which they are connected:—

Fuel; Solid Fuels; Gases; Destructive Distillation; Mineral Oils.
Tar and Tar Products.
Dyestuffs and Intermediates.
Fibres; Textiles; Cellulose; Paper.
Bleaching; Dyeing; Printing; Finishing; Laundry Work.
Acids; Heavy Chemicals; Alkalis; Salts; Non-Metallic Elements.
Glass; Ceramics.
Building Materials.
Metals; Metallurgy, including Electro-Metallurgy.
Electrotechnics.
Fats; Oils; Waxes.
Paints; Pigments; Varnishes; Resins; Plastics.
India-Rubber; Gutta-Percha.
Leather; Glue.
Agriculture.
Sugar; Starches; Gums.
Fermentation Industries.
Foods; Baking; Dairying and Milk Products; Margarine; Flour Milling; Catering.
Organic Products; Medicinal Substances; Essential Oils.
Photographic Materials and Processes.
Explosives; Matches.
Sanitation; Water Purification.

The list indicates a wide scope for the application of scientific knowledge, but it by no means covers the whole field open to chemists. Staffs of chemists are required by railways, shipbuilding yards, dockyards, arsenals, mines, agricultural experimental stations, and, apart from industries, in mints, in sewage disposal works, by Rivers Boards, and so forth.

Thus, not only in the manufacture of chemical products, but in practically all productive industries, as in many other spheres of activity, chemists are now recognised as a part of the essential organisation. They are employed in the following capacities:—

(*a*) Analytical chemists,—for the analysis of raw materials and of waters, fuels, lubricants, paints, cement, etc., checking deliveries to ascertain that they are in accordance with contracts, and the examination of intermediate products, products and by-products.

(*b*) Research chemists,—to investigate problems arising in connection with the operations of manufacture; to assist in devising new methods, introducing new products, and utilising waste products.

(*c*) Control chemists,—to devise, direct, and supervise processes on the large scale.

(*d*) Consulting chemists and chemical engineers, with experience in technology,—to advise periodically in the general progress of the work on the development of new projects and the design and erection of plant.

It would be difficult in many businesses to buy and sell to proper advantage except with the help of analytical data; or to devise new products or find uses for waste products, to solve works problems or to try new processes, without chemists. Directors of concerns on which science has a bearing must therefore either be men of science themselves or employ competent and trustworthy advisers.

Works Analysts.

The chemist starting in industrial work is not infrequently engaged at first entirely in the laboratory. Experience with a consulting chemist, where knowledge can be gained of accurate methods of analysis of commercial samples, often affords a good preparation for the works laboratory.

In most manufacturing concerns of importance a staff of analysts under the control of a highly competent chemist will be engaged on routine tests. Many such analysts have been trained in works to carry out a limited variety of operations of a more or less simple character according to their ability. Such analysts may have made their first acquaintance with science as laboratory attendants, and of these a considerable number make little endeavour, or lack the capability, to rise above ordinary routine; others, by attending evening classes and making the most of their opportunities, may improve in knowledge and skill and eventually attain positions of responsibility. Others, again, are trained men with good qualifications, taking, at first, minor positions to obtain experience. These also may find opportunities for showing initiative in the improvement of methods of analysis, or possibly in suggesting research bearing on the manufacture concerned.

It is not implied that works analysis is so rudimentary or simple that a supply of works-trained laboratory attendants is all that is desirable. Routine and control analysis in a modern works laboratory often involves the use of intricate methods, or of methods which have been recently developed and published. There is therefore scope for chemists with thorough training in analytical chemistry; indeed, the teaching of analytical chemistry in universities and colleges remains, as ever, a fundamental and most important part of chemistry, and this is nowhere more true than in the qualifications needed by a chemist in industry. The trained chemist who has at his command a thorough knowledge of up-to-date analytical methods, the capacity to devise

new ones, and perhaps has no special leaning towards works control or desire for other branches of research, will always be a useful asset in industry. In fact, some are almost entirely engaged on research into analytical methods.

For some purposes, analyses in the works laboratory must be in the highest degree accurate, as, for example, where the suitability of materials or the prices of raw material or of products must be determined by them; otherwise, rough tests only may be required, for example, when determinations of the constituents of intermediate products are necessary for the information of chemists controlling a manufacturing process. The laboratory should be so fitted and the work so organised that there may be as little delay as possible in obtaining results.

In large concerns where the responsibilities of a laboratory are considerable and the analyst is afforded the chance of investigating new methods, there should be opportunities for him to rise to a position of importance. On the other hand, where a young chemist finds himself restricted to routine work of a monotonous character in a small laboratory, with small prospect of advancement, he will be well advised to fit himself for a wider sphere of activity, which can often be found, for men with practical tendencies, in plant control and eventually in higher management.

Works Research Chemists.

Bacon would have defined pure research as "light bearing" experiments, tending towards the discovery of causes and axioms; and industrial research as "fruit bearing," tending towards the practical utilisation of the former.

Chemists engaged in the research laboratory should be qualified to attack new problems or to devise means for overcoming difficulties. The main lines of investigation lie in the following directions:—

(i) improvement of quality; detecting the causes of faults;
(ii) increase of yield;
(iii) reduction of working costs;
(iv) utilisation of waste;
(v) introduction of new products and processes.

It is not suggested, however, that there should be any limit to his domain, for the true research chemist should be allowed reasonable scope for following his inspiration, wherever it may lead him.

Every manufacturing concern of any magnitude should retain a staff of chemists for experimental research and a number of probationers to be trained for investigation in industrial problems. Conferences with control chemists and engineers should be held from time to time as the work proceeds. Profitable results are constantly obtained, and they are occasionally of such revolutionary character as to repay abundantly the whole cost involved.

Technological research is not likely to be useful and successful until it has been conducted as nearly as possible under works conditions. If the problem is one for urgent attention, or if it necessitates full knowledge of the processes involved, it is, generally speaking, of little use to refer it to anyone who has not the experience and all the starting knowledge of chemistry and physics with which those in the works are already equipped. Results depend mainly on whether the problems are entrusted to workers of the right type.

The college student and the academic teacher are, as yet, perhaps inclined to draw undue distinction between what they term "pure" and "applied" chemistry. Actually, in works which have the modern outlook, it is fully appreciated that the industrial application of chemistry demands full use and thorough knowledge of the so-called pure science. Indeed, in the successful manufacturing organisations, the technical research staffs necessarily include men whose reputation and ability in the field of pure chemistry are in no sense inferior to those of their colleagues who hold academic posts of high standing.

It is more and more clearly recognised that success as a works research chemist is most likely to be attained by those who have had super-imposed upon their purely chemical training a preliminary college training in the methods of research. It is for this reason that manufacturers tend to favour applicants who have been awarded post-graduate university degrees (Ph.D. or M.Sc.). The conferment of such a degree implies that the holder has undergone one, two or more years' training in the methods of research, in association with someone qualified to impart such training. Such training is increasingly regarded as desirable, if not essential, for those who propose to enter upon technical research.

As in other branches of chemistry, so in chemical technology, those who hold responsible positions cannot afford to neglect the current scientific literature—technical books and journals,

patent abstracts, etc.—mainly reviewing the industries with which they are concerned in the light of modern theory and practice. From studying processes and watching the development or failure of industries generally, the chemist acquires ideas which may be applicable to the particular industry in which he is himself engaged, whilst from the study of the interdependence of industries he frequently finds means of securing more advantageously the materials he requires or of disposing of products or by-products of his own concern. Problems may also be suggested by a knowledge of the special requirements of various trades. With these possibilities in view, questions affecting the utilisation of by-products and waste products are kept constantly in mind and duly investigated.

When a suggestion becomes a subject for research, records of work bearing on the subject are looked up in books and journals, and the results already achieved carefully noted; for in this pursuit, if a chemist would acquire knowledge, he must take knowledge with him. The extent of investigation may thus be shortened considerably; indeed, it may be found that the identical problem has already been solved. On the other hand, the findings of previous workers may have to be checked and augmented in the light of modern progress; a new view of the subject may be obtained and a new road found to the object sought. Often the work is tedious, calling for the exercise of much thought, skill, and patience devoted to a single problem for a considerable period of time. This is the discipline of the research chemist; but the goal may come in sight at any moment if he but persevere and maintain the will to get there.

The investigation should be directed to a definite aim. The investigator must not be prone to jump to conclusions. The solution of the problem should be pursued to its fullest development, the work being based on clear perception, sound reasoning, and keen discrimination.

A new discovery may at first be regarded as an interesting curiosity; but men of affairs are apt to measure its value according to its immediate usefulness. Though the chemist may be convinced of the utility of his projects, opposition is not infrequently raised to giving them a practical trial, even on a moderate experimental scale, until he has secured the full confidence of his directorate. Yet he should not be discouraged, but rather attempt the further improvement of his scheme in the hope of securing its reconsideration at a favourable opportunity. The

notion of "letting well alone" has often been the cause of a well-founded concern falling behind in the race of competition.

Examples of the influence of research on industrial progress would fill many volumes. Among these may be mentioned the synthetic preparation of dyestuffs—such as indigo and Turkey Red—from coal-tar. Many other colours, as well as drugs, disinfectants, fertilisers, and numerous useful chemicals, have been derived from the same source—coal-tar.

Nearly all great manufacturing companies maintain research staffs at considerable expense, and with substantial benefit.

Works-Control Chemists.

One of the primary duties of the chemist engaged in industry is to safeguard from accident those for whom he is responsible. His special knowledge must always be used for this purpose: in certain cases, such as the restoration of a man suffering from gas poisoning, the chemist is invaluable.

For example, with gases such as carbon monoxide, he can insist on efforts for revival being continued long after it would appear from a clinical examination that there was no hope of the recovery of the victim. In co-operation with the Factory Department of the Home Office, the Association of British Chemical Manufacturers has published *Model Safety Rules* for use in chemical works.

Chemists should be employed to control all operations dependent on chemical science. Their education is distinctly a training in the "law and order" of things, and fits them for control where law and order are essential to successful working. Just as certain duties are deputed to a manager and a staff of clerks in a commercial business, so highly competent chemists, in direct touch with the principals, are given authority to delegate chemical work to trained personnel in various departments. Thus, there is intimate co-operation between the business principals, the chemists on the works and the chemists in the laboratories, in order that the commercial and technical aspects may be simultaneously built up and stimulate one another.

Chemists engaged on the works are required to be well and systematically trained in the theory and practice of their science generally, because they are often confronted with problems lying outside the ordinary academic curriculum.

The following schedule abstracted from the syllabus of the examination for the Fellowship of the Institute in Branch G—Industrial Chemistry—indicates the many directions in which the knowledge and work of such chemists should extend:—

The application of well-known chemical and physical laws to industrial operations;
The development, control and transmission of heat and power;
Fittings and stores;
The properties of materials used in general construction of plant;
Process costs;
Working costs;
Economics of manufacture;
The operation of plant in general use in industrial chemical works;
The sources and character of raw materials;
The uses of finished products;
The treatment of by-products and of effluents;
The technical methods of analysis employed;
The interpretation of drawings or models of plant and fittings.

A brief consideration of such matters may be useful:—

The application of well-known chemical and physical laws to industrial operations.

In many works, the application of the laws of physics are no less important than those of chemistry. Often the success of a process depends on the provision of plant, the construction and use of which calls for a knowledge of electricity and magnetism. Students who intend to practise in industrial chemistry are, therefore, well advised to take courses in advanced Physics as well as in Physical Chemistry. Preference is given, in many cases, to those who have taken, in addition, courses in technology bearing on the industry concerned, and have thereby advanced a step towards bringing over the gap between academic training and practical experience. The influences arising from the scale of operations, and the factors of time, temperature, pressure, and concentration in large-scale operations, should all be regarded as matters for constant study in the works. The main point of this section is that *principles must be understood before it is possible to understand processes;* hence the necessity for a broad technical training.

The development, control, and transmission of heat and power.

Although this is primarily the concern of the engineer, the control chemist should have a useful knowledge of the principles of engineering. The extent and character of such knowledge will

vary according to the size and character of the works. The chemist should study the practical application of the laws of heat to chemical operations, the generation of heat by combustion, the transference of heat by radiation, conduction, and convection, the transformation of heat into other forms of energy. He will invariably find it a great advantage to be acquainted with the construction of boilers and engines; though in many works, when once the plant is in working order, he will probably have little to do with such things, because the staff will include skilled mechanics well able to attend to ordinary repairs and to effect minor alterations.

Many industries depend in a large measure on an efficient supply of suitable fuel. The quantity must be sufficient to allow for emergencies, and the quality must be suitable for the purpose. The chemist should be competent to appreciate the results of calorific tests made in the laboratory, and to advise on the value of coal and coke. He should understand the methods of sampling and analysis of fuels. Again, the treatment of water supplies for boiler purposes is a matter of great importance, involving a knowledge of the chemicals employed for softening and how they are severally applied on the large scale. Due regard should also be paid to the possibility of utilising waste heat, either in the form of exhaust steam, or outlet furnaces gases,—for instance, for drying purposes. Economy in the utilisation of water is often as important as economy in the use of fuel. Condensed steam from boilers is frequently employed in manufacturing operations.

The operation of plant in general use in industrial chemical works.

The chemist must, of course, be acquainted with the value of the raw materials of the industry, and should know something of the distribution of such materials—where found or grown, and how produced.

In the selection of a site for the establishment of a new works special regard must be paid to the accessibility of material, and to the means for handling and distributing the material on the works,—the flow through the works—and for dispatching the finished products—proximity of railways, canals and rivers.

Furthermore, modern processes—in which the finished products are often the result of many operations and reactions—demand a speedy and safe mechanical handling of materials in

the solid, liquid and gaseous states, and the industrial chemist must be at home with these important mechanical aids to chemical processes.

As machinery in an increasing degree takes the place of labour, so the chemist should become acquainted with engines and the plant employed in manufacturing operations, including boilers, pumps, presses, refrigerators, cranes, conveyors, and so forth, and he should be able to supervise in a general way the proper disposition of such plant and to know something of the method of maintaining it in working order.

The plant, of course, varies very greatly in different industries, and may include such as is necessary for the preparation of materials by breaking, grinding, pulping, levigating, washing, steaming, bleaching, filtering, crystallising; or for evaporation or desiccation; or it may be for processes involving electrolysis, fusion, distillation, refrigeration; or possibly for the handling of large volumes of gases under various conditions of temperature and pressure.

The chemist should lose no opportunity of gaining an acquaintance with the accessories of the work generally. The value of his services will increase in proportion to his understanding of the whole scheme. In the course of time, as he becomes better acquainted with the processes involved, he learns to appreciate the influence of scientific method on large-scale operations. He learns this part of his business, much as an engineer does,—by practical experience. He should not be too fastidious about taking off his coat and making his hands dirty. He may, in emergencies, have to handle implements or materials himself, or to go into plant to inspect its inner machinery; in fact, to do anything that the workmen under him are required to do. He should aim at becoming as familiar with any part of the plant as the workers who are regularly engaged on it; otherwise he will find it difficult to control those under him and to instruct newcomers. If he is not prepared, at any time, willingly to take a part in the hard work of a factory, he will be well advised to turn his attention to some other branch of the profession.

The chemist, moreover, may be required to advise on questions of ventilation, to provide safeguards against fire and explosions, or against poisoning or other dangers, such as injury from dust arising from grinding processes; and to devise means for the prevention of pollution of the air with noxious gases from chimneys, and of rivers and streams with objectionable waste

liquors. He may have to take an important part in modifying existing plant, or in advising on the construction of new plant for the translation of a laboratory operation into a large-scale operation. Ability to advise in such matters implies the faculties of initiative, ingenuity and resource, combined with knowledge of technology which can be attained only by experience.

The waste products of certain industries may be the raw material of others, so that the problem is often pursued with most advantageous results,—in some cases, of such far-reaching importance that a subsidiary branch may, in time, even supersede in importance the initial manufacture.

The properties of materials used in the construction of plant.

The chemist is expected to be acquainted with the possible reactions between materials used in the construction of vessels or piping, and the substances they are intended to contain or convey. The choice of material may be limited on this account, due consideration being given to the relative cost of various materials resistant to such reagents, as well as to the size of the vessels and their general adaptability to requirements. This involves some knowledge of the current prices of metals—iron, copper, lead, zinc, aluminium—and of wood of different kinds, glass, rubber, and other materials. The study of the properties and uses of alloys, particularly alloys of nickel, of chromium, of manganese, special steel, etc., has led to many important and valuable improvements in the production of machinery and plant. The physical properties of materials of construction—timber, iron, steel, masonry, etc.,—their resistance to stress and strain, and possibly their conductivity of heat or of electricity may also have a bearing on their suitability for the purposes for which they are to be used. The methods of preserving materials against weathering may also come within the purview of the chemist, who should be acquainted with various forms of preservative paints and should know, for example, why brick is often to be preferred to stone in factory construction, and the objections to the use of lime from magnesian limestone in the mortar employed.

New inventions rapidly effect great changes in industry, and large sums of money may be involved in any new step. Thus, the introduction of new methods may render obsolete costly plant which must be scrapped unless it can be adapted to new conditions. The responsibility of the chemist in such matters may be very great.

The interpretation of drawings or models of plant and fittings.

To be able to make a sketch of a proposed structure or piece of apparatus—large or small—giving dimensions, or at any rate a fair idea of the relative proportions of the various parts, is of great assistance in explaining requirements to engineers, architects, apparatus makers, carpenters, plumbers, etc. Similarly, to be able to interpret plans and sectional drawings prepared to scale, and to visualise the finished structure or apparatus, is of importance in order to avoid making subsequent alterations. In improvising experimental apparatus and half-scale plant, such ability is invaluable. It necessitates sometimes an acquaintance with the common engineering terms, which with other useful information can be obtained by taking a friendly interest in the fitters' shop as occasion arises.

Process costs; working costs; economics of manufacture.

When a new project is suggested, the chemist should be able to prepare a business-like cost sheet, showing clearly the cost of the materials and plant required, the cost of handling and manufacture, and the value of the probable output. Without it he is unlikely to be allowed to proceed with the proposition. It must be submitted to the test of profit and loss. The economic side of the business cannot be placed in the hands of men who have no knowledge of matters of this kind.

The chemist, in his college training, has not often been concerned with *values*—cost of material, cost of labour and working expenses. He is given, perhaps, a sample of a substance containing a valuable constituent which can be extracted profitably on a small scale. He must not be content with first impressions on the subject. The process proposed may be quite good, but the business of transporting and handling material and products in bulk, the disposal of by-products, the utilisation of "waste" and a host of other questions must be answered before the business man or the directorate is satisfied.

Unless the works are run at a profit, they are not likely to run for long. Besides looking constantly for means to improve the processes employed, saving waste, or otherwise perfecting the general control of his part of the work, the chemist should keep careful records of the progress made. If the process is such that it may be regarded in the light of a laboratory operation conducted on a large scale, he should be able to determine

whether and in what respect the result falls short of what should be expected—the theoretical yield—and may find in this problem the prospect of referring to the research laboratory investigations of far-reaching consequence. The checking of material and the tracing of losses through the various operations of a process will involve careful analytical tests, for which, being of a routine recurring character, special provision should, as has already been mentioned, be made by setting up the necessary apparatus as a permanent part of the equipment of the laboratory. It is sometimes found advantageous to use vessels and apparatus simulating—in their general arrangement, structure and material—the plant used on the large scale, and, in such cases, ingenuity is needed to reproduce the operations of the works on a small scale. The reports of the laboratory afford all-important guidance in the general control of operations, pointing to increased efficiency in output and economical working.

Everything—and everybody—coming into the works has a value, and there must be a maximum return to be aimed at, based on scientific as well as business data, having regard to all costs—raw material, fuel, water, labour, general running and trading expenses—in their relation to the value of the products.

The aspirant to a position in chemical industry is in a much stronger position if he can regard, with interest and enthusiasm, considerations of economic factors, labour, and social conditions, which are in fact involved in the complete scheme of production and marketing. In some sense, each of these factors may be regarded as a condition to be taken into account, in addition to the ordinary chemical or physical conditions such as temperature, concentration, pressure, and so on. Looked at in this way, the application of chemistry to manufacturing problems becomes more complex and interesting than purely laboratory chemistry, and not, as some seem to think, a kind of degradation of a pure science to an applied art. The chemist who has so narrow a conception of his science as to feel that these wider considerations detract from the value or interest of the study of pure chemistry is not likely to be of much use to chemical industry. On the other hand, the chemist who is interested in these wider factors and regards them as additional incentives to the solution of problems which, taken as a whole, are more complicated than those of the laboratory, has the right approach to his functions as a technical research chemist; moreover, his is the type of mind which will not only be successful in works research, but will more

and more in demand, with increasing experience, to take part in the administration and direction of enterprising businesses.

Obviously, then, the control chemist must know a good deal of what is called *business;* so varied and divergent are the matters which come within his purview that he cannot afford to lose any opportunity of gaining experience and knowledge of almost anything. He may with advantage learn something of insurance of various kinds, political economy and taxation, mercantile law (covering such matters as contracts, specifications, partnerships), company law, and patent law. Sixty years ago, a writer in the *Chemical News*[1] expressed the view that a "works" chemist should after a thorough technical training, including "volunteer" experience of two or three years in works, make himself master of the differential and integral calculus, of descriptive geometry, mechanical technology, machine-making, architectural planning and designing, and land surveying!

It is hardly possible, of course, for any man to meet all these requirements; but many chemists, in the course of a few years' experience, have fully shown their ability to deal with emergencies as they arise, and have thereby become firmly incorporated in the concerns to which they are attached. Such men are essentially *practical,* possessing the faculty of doing things, not necessarily in the best way, or the most expedient, or the quickest, but the most reasonable in the circumstances, while they are conscious of their limitations, and know when to call in more expert advice and assistance.

Chemists in works are often appointed under contract for a term of years at a remuneration increasing by increments at stated periods, the appointments being renewable at the end of a term, and subsequent advancement being dependent on results achieved. Sometimes it is stipulated that all the results of their work during the period of the contract become the property of the principals, but the chemists on their part may be able to stipulate for a share in the profits accruing, both during and after the termination of the period of appointment, from inventions or improvements introduced by them. The latter course is obviously a more encouraging arrangement for the chemists.

Frequently the success or failure of important operations depends entirely on the knowledge and skill of the chemist in charge; but although he may be responsible for operations upon

[1] 11th October, 1878.

which large financial interests depend, he is not always rewarded on a commensurate scale. In all these matters, however, the personal character and capacity of the individual are dominant factors. Some manufacturers are apt to regard chemists solely as analysts, whilst others expect them to solve with ease problems of great technical difficulty.

It is commonly said that scientific and business ability are not often combined in the same individual; but if a careful inspection is made of the registers of members of the representative chemical bodies, a high proportion will be found of those who have made themselves not only fully cognisant of the science underlying the concerns to which they are attached, but have become thoroughly successful men of affairs.

General Considerations.

When an industry based on scientific principles fails, the science side of it will be blamed; if it succeeds, the business side of it will be praised. Yet such industries have passed from one country to another entirely on the failure of business capacity in their directorate. The proximity of the supply of suitable raw material may be a dominating factor; the ill-considered selection of a site may render profitable working impossible; but the want of appreciation of suggested improved methods or apathy to schemes for the utilisation of waste products not infrequently contribute to failure. The main demand is for competent men of science who are men of business, to whom great manufacturing concerns can look to enable them to maintain their position in scientific industries. There is always a demand for men of the right stamp, men of practical ability, imagination, initiative, and energy, who are capable of grasping the full significance of large-scale operations. When once they have established themselves they can usually find success in an industrial career. Many have proved themselves to be so invaluable that they have become managers and directors, and thus the number of scientific men in control of industries has been steadily increasing during the past thirty years, while, as a consequence, there is a feeling of greater confidence between manufacturers and their chemists.

As already mentioned, the right type of trained chemist will become increasingly in demand for assistance in the control of businesses, and not merely of chemical processes. In the past, even chemical concerns have frequently been directed by those

having commercial or financial ability but having little or no knowledge of chemistry. As time goes on, if the industry of this country is to hold its place, the Boards of Directors will consist more and more of teams in which scientific ability is represented equally with financial, legal or exclusively commercial acumen.

The industrial chemist should be acquainted with Acts, Orders and Regulations which may have a bearing on the industry in which he is employed. A summary of legislation is included in an Appendix to the *List of Official Chemical Appointments* published by the Institute of Chemistry (Ninth edition, 1937).

Consulting Technologists and Chemical Engineers.

Consulting chemists who are available for advice on technological matters have usually had considerable experience in industry before establishing an independent practice, and some have acquired, as an adjunct to an analytical practice, special experience in certain branches of manufacture. Thus, there are metallurgists, assayers, and mining chemists; fuel and gas technologists; specialists in refractory materials, pottery, porcelain, glass, cement and building materials; technologists concerned with petroleum and other oils; chemists devoting special attention to the brewing, fermentation and sugar industries; chemical advisers on textiles, paper, rubber, leather, dyes, explosives, and so forth; and chemical engineers (p. 50). There is in this country a considerable body of such men who occupy positions analogous to specialists in other professions, and may be called into consultation in cases of difficulty, to advise on new projects, to revise methods of working, or to assist in arbitrations, in matters of litigation affecting patents, and in special inquiries.

Chapter VIII

PROFESSIONAL PROCEDURE

It is clearly material for every student preparing for a professional career to know something of his obligations as well as of his privileges. These obligations affect mainly his ideas of loyalty, discipline, and unselfishness. All who are concerned with the advancement of professional interests recognise that it is as essential to maintain a high standard of conduct and to create a fellowship conforming to recognised ethics as it is to maintain a high standard of competency.

Any departure by a professional man from the accepted code renders the offender liable to have his conduct enquired into, with the possibility of reprimand, or suspension or expulsion from his professional institution. The ill-considered action of an individual member may affect adversely his profession as a whole in the estimation of the public. It should be a matter of personal concern for everyone to assist in maintaining the reputation of his calling by refraining from any doubtful course of action. These matters are largely questions of *taste:* good taste is the proper appreciation of what is fitting. However, each practitioner must beware how he judges others, since the circumstances may be imperfectly known and not appreciated except by those most intimately concerned. Intentions may be good and motives correct, or presumed offenders may be more sinned against than sinning.

The chemist in private practice must use his own judgment, acting according to his conviction of what is right, bearing in mind that his conduct in the early days of practice will probably influence his subsequent career. He may be free to place what value he pleases on his time and professional knowledge and skill: the public take men very much at their own estimation and expect to get what they pay for. Fees may vary with the circumstances—for example, the financial interests and responsibility involved—but each practitioner should realise his position as a member of a profession and endeavour to conform to its standards. His education and technical training give him a definite status and warrant him in supporting the profession generally by requiring adequate material reward, without having recourse to unfair practices.

Attempts have been made to formulate schedules of fees for analyses, but the conditions of practice are so various that it is impossible to authorise a scale applicable to all circumstances, having regard to such considerations as the locality, the value of the work to the client, the nature and scope of the investigation required, and the professional status of the chemist concerned. Chemists may be equally well qualified, but some will place a higher value on their services than others. At the same time, professional men are under a common obligation to one another not to create a competitive spirit or to "under-cut" deliberately the fees commonly charged for any particular kind of work. Each individual is expected, in this as in other matters, to support the position taken by his profession as a whole, and to be prepared on occasion to make some sacrifice in the general cause. The main point for every practitioner is to avoid any course of action which is likely to injure the interests of his profession. In any case of doubt, an older practitioner will usually be found ready to give a beginner the benefit of his views on such matters.

The maintenance of the status of a profession cannot be secured solely by ensuring the competence of those who practise. Those who cannot command proper recognition for their services, in the form of adequate remuneration, obviously have no status. The adoption of a low standard is a fundamental error which is very difficult to rectify, attracts the least desirable forms of practice, and is injurious to the profession generally. "That which is not for the interest of the whole swarm is not for the interest of a single bee." (*Marcus Aurelius.*)

The chemist can only establish his position by good work and integrity. He must keep himself informed of the current work in his science, and be ready to cope with any problem reasonably within his sphere of practice. He should devote the best of his knowledge and skill to the interest of his client, or his employer, but it is sometimes questionable whether he should undertake difficult problems outside his usual work; indeed, he may run the risk of failure, and his reputation may suffer, since men who pretend to omniscience are apt to be discredited. Sooner or later such pretence becomes unbearable: "the mask becomes an instrument of torture." The consulting chemist, when in doubt, can refer a client to a practitioner having special experience in the subject, or, if his client prefers to retain him in the matter, suggest a conference with a specialist. Much will depend here

on the intimacy of his relationship with his client; but if he undertakes the work he should not hesitate to point out that it is special in character and out of his usual sphere, and that he is relying on his general scientific ability rather than on special knowledge. Tact comes with experience. In any case, to talk over the heads of clients, to resort to mysticism, or to conceal facts by a vague style, will not secure confidence. It is equally dangerous to form hasty conclusions without full investigation of facts. Advice should be directed to some practicable, and not merely to an ingenious, solution; if it is destructive in character, something constructive will be looked for as a reasonable substitute.

That kind of competition which takes the form of self-advertising or appealing in any irregular manner for patronage is properly discountenanced, as is also the giving of "trade puffs." Advertising is seldom resorted to by professional men: medical men, barristers, solicitors, and members of the Stock Exchange are forbidden under severe penalties to advertise. It is not only a question of taste, but amounts to an admission that those who resort to it are unable to secure a clientele by legitimate means.

A passage from Boswell's *Life of Johnson* is interesting in this connection:—*Boswell:* "You would not solicit employment, Sir, if you were a lawyer." *Johnson:* "No, Sir, but not because I should think it wrong, but because I should disdain it." Boswell's comment on this was that the doctor had made a good distinction, which would be felt by men of just pride. Johnson proceeded: "However, I would not have a lawyer be wanting to himself in using fair means. I would have him inject a little hint now and then to prevent his being overlooked." There should be no difficulty in a man of good sense determining for himself the manner of injecting the "little hint." It should clearly not be by means of advertisement, or personal soliciting, or by deliberately striving to deprive another practitioner of a client.

The giving of trade certificates for "puffing" purposes is regarded as an indirect form of self-advertisement. Nothing reflects so much discredit upon a professional chemist as the issue of certificates in favour of questionable articles, or such as contain merely laudatory or irrelevant statements. It is quite unjustifiable, also, to give publicity to comparisons between the products of a client and those of other firms in the same

trade. The chemist is expected to be correct in his statements, and to found his opinions on facts. The best method of investigation known should be used and all data ascertained by careful experiment, properly confirmed. Reports should be in definite and intelligible language, and should neither be liable to be misunderstood nor capable of being misinterpreted.

A chemist should decline to undertake work the report on which he is aware will be used for an improper purpose. A report on a single sample can only refer to that sample: it is no guarantee of the bulk production for more than a short time, and the certificate should be so worded as to make it clear that it does refer only to the sample in question. Cases have occurred in which it has been clearly proved that false reports have been published under the names of well-known practitioners, and others in which reports have been used without any authorisation, or garbled, or abbreviated by the omission of essential statements. Similarly, there have been cases where chemists in industrial employment have been asked to concoct false reports on processes in connection with the issue of questionable company prospectuses. Obviously it is detrimental to the interests of his profession for a chemist to be associated with any organisation which adopts questionable methods of conducting business, and such association may bring him into disrepute among his professional brethren.

The chemist engaged in matters of legal and quasi-legal enquiry may be brought prominently to the public notice, and his position is often one of great difficulty. He has to do his best for his client, even if the latter is in the wrong, but he should adhere strictly to the facts. He is not a witness by profession, but a professional witness, and his duty is to assist in the proper determination of the subject of dispute, by giving his evidence clearly and truthfully. Facts must not be distorted to convey a wrong impression to the uninitiated; when the other side is heard, such artifice will usually recoil severely on those who attempt it. The chemist, when consulted on a matter which is likely to be the subject of litigation, should explain the position clearly and impartially to his client, and should point out that his evidence must be in accordance with the facts determined. He cannot commit himself to giving a favourable opinion beforehand, as he may sometimes be expected to do, and he must risk the displeasure of his client in this, if he values his good name and professional position. He cannot allow

himself to acquire a reputation for bolstering up unsatisfactory cases.

The conflicting testimony of equally qualified experts is in most cases attributable to the circumstance that neither has had the full facts brought under his notice. The chemist may not be in possession of all the essential facts; he may unwittingly be asked to undertake an investigation with only part of the material facts before him, and may be led into committing himself to an opinion which would be modified if he were more fully informed. In some cases the employment of chemical referees as a kind of court of arbitration, or the provision of means whereby the advisers of both sides can meet in consultation, may prove a great saving of expense to those who would otherwise be litigants. This system may result in the reduction of the work or fees of chemists engaged, but that should be more than counterbalanced by the desire to assist in the proper settlement of such matters, and the recognition that fewer reputations are injured and much unnecessary expense saved to those from whom the profession derives practice or employment.

The main ethical point is the observance of respect for the other side: a professional man should not disparage another member of his profession, and should avoid forming an unfair estimate of an opponent merely because the latter happens to hold opinions contrary to his own. The facts have probably been presented to each in a different light, and one or the other may be possessed of additional information. Caution in criticism of the work of others is always advisable. Adverse criticism of the opinion of another is not the function of the professional witness. Both are engaged in a common duty for the service of the public, and should appreciate the idea that their profession constitutes a bond of fellowship, even though they may not always agree. The chemist may be compelled to contradict the opinion of another, but this can be done with courtesy. His business is to substantiate his own views, which must be founded on his knowledge deduced from scientific experiment and established fact. The accuracy of instruments and vessels, purity of reagents, etc., may be questioned, but he should be careful how he exposes what he considers mistakes on the part of his opponents. He will be wise also to guard against talking of the case while it remains undecided.

Scientific evidence, if it is to carry conviction, should be

precise and definite, and given with caution and moderation. It should be given clearly, and in language reasonably free from scientific terms not easily understood by judges or ordinary jurymen. The results of actual work in the experience of the chemist are of more value than any opinion derived from books. Even if his answer is adverse to the side for which he is acting he must give it frankly, although he may be able to add qualifying expressions by way of explanation. Fencing with cross-examination or shirking questions will not command confidence; the volunteering of information is frequently unjustifiable or it may be misinterpreted, being regarded as an attempt to change the course of the evidence.

The scientific witness may decline to answer questions outside his knowledge; he may be able to ask for time to consider, or opportunity to experiment. If, in a subsequent case, a chemist expresses an apparently different opinion on a point, he should be ready with reasons justifying his change of view. To each question put by counsel he is expected to give a direct answer, and his manner, whether prompt or halting, may not be interpreted correctly. He may be sensitive, sometimes, about answering questions, but it is his duty to testify to facts or to give his opinion, as the case may be, on matters which are special to his knowledge, in order that the court may give due weight to his evidence; the questions put to him, therefore, should deal with his science and skill. No one is entitled to consider himself infallible; so that, if on being confronted with an opposite view, a chemist who is to be called as a witness feels disposed to vary his own, his client should be informed as soon as possible, in order that he may be spared further litigation. The reputation of the chemist himself will suffer less than if he allows his client to proceed with an action, the result of which cannot be satisfactory.

Public Analysts and the Official Analysts to the Home Office are called in for investigations arising in connection with cases of suspected poisoning, or it may be for the identification of blood-stains in cases of suspected murder or foul play, or in other criminal investigations. In such matters, possibly involving evidence on which the life of a human being may depend, the necessity for skilled experts is clear, and it is equally obvious that what they state as fact should be absolutely established and that their opinions should bear the most stringent examination. They may be the only professional witnesses called, and

it is their duty to place every fact before the Court which will tell in the prisoner's favour as well as those which will tell against him.

Probably there have been few better examples than that of Sir Thomas Stevenson for the straightforwardness and certainty of his evidence. The importance of the cases in which he appeared made him subject to the most formidable kind of cross-examination, but he could not be led into giving any opinion not definitely founded on facts. Lord Brampton—Mr. Justice Hawkins—before whom Sir Thomas frequently gave evidence, said of him that he was convinced that he was always right in his evidence, adding that he had always respected him for his courage and candour and truth; and after sixty years' experience in the law, if he were asked to name the man on whose evidence he could most implicitly rely, he would turn to Dr. Stevenson.

In recent years there has been an increase in the number of counsel and judges who have sufficient technical knowledge to enable them to grasp the details of scientific cases. Suggestions have been advanced for the formation of juries composed of scientific experts, but such an arrangement would scarcely be satisfactory; probably their own opinions would be at variance, and not of greater value than those of the opposing experts.

Chemists may be called upon to act as Assessors to assist the Court and to give evidence; or, under a recent Order,—XXXVII A of the Rules of the Supreme Court (R.S.C.)—may be appointed as "Court Experts" to enquire into and report on any question of fact, or of opinion not involving any question of law or construction. In whatever capacity they may be called, it is clearly necessary that they must give scrupulously fair evidence.

So far, this chapter has dealt largely with the relations of the independent practitioner to his clients and professional brethren; but the majority of chemists are engaged in industry, or otherwise as employees, and in that connection they are expected to observe their obligations to their employers and to those with whom they are associated in their work. Here, the predominating characteristic expected of the chemist is loyalty, implying an honest endeavour on his part to give his best service to his employer, and to deal fairly with his colleagues. His relations to his employer may or may not be defined in a contract of service, but he should not sign a contract except in good faith, or think that he will be able to evade obligations which are not specifically expressed but are implied and understood

in all such negotiations. He must remember that he is paid for his services, and if, for example, he is a research chemist, he must not for one moment think of attempting to conceal any of the fruits of his labours which are likely to be profitable. The successful research chemist soon becomes indispensable; but one who is not devoted to the interests of his principals can certainly not be retained indefinitely. He must of course carefully avoid talking of his work and the affairs of his employers to those who are outside the business.

If he has the spirit of loyalty and shows himself keen, his employers will not be anxious to part with him unless circumstances compel them to do so.

In his relations with his colleagues he will find that it is always to his own and the general advantage to play for the team and not only for himself: he should unstintingly give credit where it is due, and be cautious how he criticises, or imputes blame to, others. There should be no thought of taking a mean advantage of the ideas disclosed by a fellow-worker, but reciprocity in the frank expression of opinion and a free exchange of ideas for the common benefit.

Some of these practices are hardly such as may ordinarily be presented to Board of Censors, but among men of science a man is held in high esteem who freely acknowledges help when he receives it, and accepts with modesty the praise or reward which is his due.

Among the Romans the office of Censor was much revered; it conferred great powers, especially in examining men's lives. Professional bodies of our time also appoint Censors to investigate complaints regarding the professional conduct of their members. By the influence of the Censors of the Institute of Chemistry and by conferences on matters of this kind much has been done to bring about a high standard of professional procedure in this country, so that there exists among our chemists a sense of mutual responsibility in their relations to one another and to the public.

Professional codes have also been formulated by the American Institute of Chemists, the Australian Chemical Institute and the Canadian Institute of Chemistry.

Chapter IX

CHEMISTRY AND THE STATE

The Department of the Government Chemist, whose headquarters are at the Government Laboratory, Clement's Inn Passage, Strand, London, is an independent Department. It controls branch laboratories at the Custom Houses of London, Liverpool, Glasgow and other ports, at the Museum of Practical Geology, at the Army Supply Reserve Depôt, and at H.M. Office of Works Stores. The duties of the Government Chemist and his staff include (1) those laid upon him directly by Act of Parliament, (2) those devolving upon him indirectly by virtue of the advice he gives to other Government Departments directly charged with duties under Acts of Parliament, and (3) those extra-statutory services rendered, by Treasury sanction, to all other Departments of State needing them.

Examples of (1) are:—The examination of reference samples under the Food and Drugs (Adulteration) Act, 1928, which provides that one-third part of a sample taken under the Act can be referred to the Government Chemist by magistrates who require his opinion, and must be so referred at the request of either party to the proceedings; samples taken under the Fertilisers and Feeding Stuffs Act, 1926, which permits analysis under the direction of the Government Chemist to be demanded in respect of the "reserved" part of a sample in dispute; while the Pharmacy and Poisons Act, 1933, appoints the Government Chemist or one of his staff to a seat on the Poisons Board.

Examples of (2) may relate to investigations of:—Imported food-stuffs, for the Ministry of Agriculture and Fisheries under the Food and Drugs (Adulteration) Act; flour and "offals," for the Wheat Commission; material suspected to come within the Dangerous Drugs Act; articles imported, under the Safeguarding of Industries Act and under the Dyestuffs (Import Regulations) Act; produce, under the "National Mark" scheme; "patent" medicines, under the Stamp Acts; dangerous goods, under the Merchant Shipping Act, alcoholic liquors and preparations, certain chemicals, tobacco and its products, matches, artificial and natural silk, cocoa and sugar products, hydrocarbon oils,

under various Revenue enactments; articles under the Import Duties Act and the Ottawa Agreements Act.

Examples of (3) include:—The determination of the salinity of sea-water for the Permanent International Council for the Exploration of the Sea; the recovery of radium for the Treasury; control of the quality of stores supplied to Government Departments on tender and on contract; opinions and advice on the quality and treatment of water for drinking, for bathing and for boiler-feed purposes; supervision of photographic technique for the Government Cinematograph Adviser; opinions on the cause of corrosion of lead-covered cables.

The variety of the work done by the staff is considerable, seeing that it includes the analysis of widely differing products, and necessarily the continual improvement of methods of analysis; but there are further features of the work not indicated by the mere numbers (some half a million a year) of samples for the examination of which the Government Chemist is responsible, such as the giving of advice in connection with these products and the giving of evidence before the courts and before departmental and other committees.

The established chemical staff of the laboratory consists of the Government Chemist, the Deputy Government Chemist, six Superintending Chemists, eleven Senior Chemists, four Chemists (Higher Grade), forty-two Chemists and nine Assistants II. The temporary unestablished staff, appointed by the Government Chemist, consists of Assistants III and Laboratory Assistants. The whole staff numbers about two hundred and seventy.

The post of Chemist is subject to competitive selection under the Civil Service Commissioners. The age limits are twenty-three to twenty-eight, and candidates must possess a University degree with first or second-class honours in Chemistry, or the Associateship of the Institute of Chemistry, and they must have had not less than one year's post-graduate experience in chemical work.

The post of Assistant II has been filled hitherto from Assistants already serving in the Laboratory.

Other Government Departments have laboratories for special purposes.

The Admiralty Chemical Service is constituted as a "Chemical Pool" under the Director of Scientific Research and comprises establishments at Portsmouth, Holton Heath and Sheffield, staffed from the Pool as circumstances require. These establishments are concerned with the examination of all Naval War

Materials, stores, etc., and deal with chemical matters arising in connection with construction, maintenance and the general efficiency of the Fleet and its services.

A staff of chemists is also employed at the Royal Naval Cordite Factory and there are individual chemists employed in various special capacities in the Admiralty Scientific and Technical Pools. Chemists are also employed as Technical Examining Officers in the Victualling Yards, and as Professor, Lecturers or Masters in the Naval Colleges.

The War Office has its scientific advisers, and considerable staffs of chemists who are engaged for research and inspection work, as well as for the supervision of the manufacture of war material, at arsenals, factories, and controlled establishments. In the Department of the War Department Chemist, the scientific staff consists of various grades of Chemist and Assistant. Each grade, with the exception of that of Laboratory Assistant, includes a certain number of established posts. The minimum qualification for appointment as Chemist is the possession of a University Degree with first or second-class honours in Chemistry or its equivalent. Appointment to the grade of Assistant III and higher grades is made on the recommendation of a War Office Selection Board and, in the case of established posts, is subject to the issue of a certificate by the Civil Service Commissioners. Vacancies in the higher grades may be filled either by promotion from lower grades or by direct entry, the former course being adopted whenever suitable candidates are available.

The Research Department at Woolwich Arsenal is an establishment maintained by the War Office, Admiralty and Air Ministry and is administered by the War Office. It is divided into four directorates,—Explosives, Metallurgy, Ballistics and Radiology, a number of chemists being employed in the first two.

The general function of the Explosives Research Directorate is to carry out research on all aspects of explosives. This includes the development of improved methods of manufacture and use of existing explosives, the discovery of new explosives and the improvement of ammunition. Investigations are also carried out on many non-explosive materials which find an application in the production of munitions. The Directorate assists in the investigation of difficulties occurring during the use of ammunition in the Services and is responsible for advice on its safe storage and maintenance. It acts as technical adviser to the Home Office on matters connected with industrial explosives and police

investigations and carries out a considerable amount of work on Air Raid Precautions. The research staff, numbering about eighty, is recruited mainly from the ranks of organic and physical chemists together with a proportion of physicists. In addition to the foregoing there are some 40 technical assistants of whom the higher grades must be graduates. The Metallurgical Branch of the Department, of which the research staff numbers about twenty-five, is concerned with metals and alloys, both ferrous and non-ferrous, used for service purpose, and with the metallic components of ordnance and armament. It includes sections dealing with metallography, strength of materials, electrodeposition, and metallurgical analysis.

Professors of Chemistry are attached to the Military College of Science, Royal Army Medical College, Royal Military Academy, Wellington, etc. Chemists are also attached to the Air Ministry, to the aircraft factories, the Aeronautical Inspection Department, etc. The Chemical Defence Research Department carries out research and experiments required by the three services and employs staffs of chemists and physicists on such work.

The Ministry of Agriculture and Fisheries is concerned with the administration of the Fertilisers and Feeding Stuffs Act and the approval of appointments of official agricultural analysts. The Ministry has its regional advisory chemists to advise farmers and to investigate soil problems. These officers are usually attached to a University or Agricultural College.

The Home Office has its duly appointed official analysts, whose services may be called upon in connection with the investigation of crime, and chemical advisers on explosives, petroleum, and matters arising in connection with the administration of the Factory Acts, etc.

The Ministry of Health and the Department of Health for Scotland are responsible for the administration of the Food and Drugs (Adulteration) Act, involving the confirmation or vetoing of appointments of the Public Analysts to the counties and burghs. The Ministry possesses a laboratory attached to the Department of the Chief Inspector of Foods. The Ministry is also concerned in the administration of the Alkali, etc. Works Regulation Acts, 1881–1906, under which chemists are engaged as inspectors for the administration of the Acts. The Welsh Board of Health, Cardiff, deals with the appointments of Public Analysts in Wales.

The Board of Trade appoints the Gas Referees under the

Gas Regulation Act, and also has the assistance and advice of chemists at the Patent Office and in the Industries and Manufactures Department.

Chemists are attached to the Engineering Department of the Post Office, for research and examination of engineering stores.

Chemists are also appointed assayers to the Royal Mint, the Bank of England, and the Assay Offices.

The Department of Scientific and Industrial Research employs a large number of chemists both directly at the National Physical Laboratory and the Chemical Research Laboratory, at Teddington, and at Research Stations dealing with building, roads, forest products, fuel, coal, food and indirectly in the laboratories of the Industrial Research Associations which are State-aided. The Department also affords grants for a considerable number of other research workers at Universities and Colleges.

The London County Council has a chemical staff for investigation on behalf of its many departments and for gas testing, and many county and municipal authorities employ, in addition to public analysts, official chemists as water examiners, gas examiners, sewage works chemists and managers, as well as official agricultural analysts under the Fertilisers and Feeding Stuffs Act.

A List of Official Chemical Appointments, issued periodically by the Institute of Chemistry, contains information with regard to these and other positions held by chemists in the Government and Municipal, Public Utility, Water, Gas, Electricity, and Transport Services, in Great Britain, in Northern Ireland, Eire, and in the Overseas Dominions of the Empire.

Chapter X

TEACHING

Before the middle of the nineteenth century the teaching of chemistry in the Universities and Colleges was mainly of an elementary character. Few students took a systematic course of training in chemistry, and consequently there were few chemists. It was usual for professors and practitioners alike to undertake both teaching and practice: professors more commonly than now, held appointments as consultants, and some acted as public analysts; private practitioners, in many cases, took articled pupils. When the facilities for obtaining instruction became greater and the profession increased in numbers and activity, this overlapping of work led to controversy; but, in the course of time, the educational work of the teachers increased and the tendency of practitioners to take pupils, except for special training, decreased; so that a better understanding arose with regard to the two spheres of work.

As the chemist who wishes to become a teacher has himself been through the process of being taught, he may be assumed to know a good deal about it when he starts on his career; but a few remarks on what is certainly one of the most difficult branches of the profession may here be introduced.

The methods of teaching science, or indeed any subject, are not fixed. Some students appear to require more individual treatment than others, and every teacher is confronted with the difficulty of getting the best out of his students. Every teacher ought to be a skilled manipulator and have the ability to present facts and results in a methodical manner. He should set an example to his students; they are very apt to imitate him, and bad habits are learned just as easily as good ones! Furthermore, those who do not possess the personal characteristics necessary to a teacher—enthusiasm, patience and tact—will probably be the first to recognise the advisability of turning to another branch of work.

Chemistry as a subject affords endless possibilities of arousing interest both by practical demonstration and by illustrating the application of its principles to the affairs of everyday life—health, industry, commerce,—and also of the State. Students

have to be trained, not only in the methods of conducting experiments, but in observing, recording, and interpreting results, and in the wider meaning of the work—how it may be applied to practical purposes. The spirit of enquiry must be maintained from the beginning if the student is to become an investigator or something more than a routine worker. Students should be taught how to have a respect for, and to realise the value of, the various chemicals and scientific instruments with which they are entrusted. Priced catalogues of chemicals and apparatus should be available for consultation in all chemical departments.

Not a few chemists show evidence of having suffered in their youth and inexperience from accidents in the laboratory, and, therefore, it should not be out of place to suggest that students, before they are left to their own devices, should be warned of the risks of handling dangerous substances. The careless handling of a bottle of sulphuric acid has caused the stopper to jump and the liquid to spurt, so as to deprive a boy permanently of the sight of an eye; a retarded reaction in a test tube held near the face has produced the same unfortunate result. Burns, arising from thoughtless handling of highly corrosive or inflammable substances, and cuts, from injudicious performances with cork-borers and glass tubing, are far too common accidents of the laboratory. Such disasters are apt to have far-reaching after-effects, apart from the accompanying damage to instruments and property. First-aid supplies should be readily available in every laboratory.

Litigation has arisen occasionally from the carelessness or ignorance of pupils and, in some cases, teachers have been deemed liable to damages for neglecting to provide adequate safeguards. Some form of insurance should be provided against accidents in laboratories in schools and colleges.

The teacher must, of necessity, have a sound knowledge of his subject; the successful teacher also possesses the ability to impart his knowledge and enthusiasm. He finds, too, just as much as the practitioner, that he must keep in touch with current theory and practice, and constantly revise his courses accordingly. In recent years, the Institute and its Local Sections have helped the teacher in this way; lectures dealing with advances in the various branches of chemistry are given frequently by specialists. Another important function of the teacher is to advise students on the use of books both for

theoretical and practical work, so that they may seek for themselves information bearing on the problems before them and so determine the methods to be applied. The teacher should also have access to new literature, since chemists generally find progress very difficult without up-to-date works of reference.

The teacher, moreover, if he is a student of human nature, is afforded exceptional opportunities of pursuing that alluring subject; for not only is chemistry to be taught to those who intend to be chemists, but in a less degree to engineering and medical students, and many others. The practical nature of his subject necessarily brings him into close relation individually with those who are specially drawn to it. He will mark their different temperaments, finding some students casual and disinclined to bestir themselves, while others are industrious and cover the ground quickly. Yet the latter are not always the more successful: in some students the knowledge attained is but superficial; in others, perhaps slower, it is more thoroughly assimilated. He will endeavour to understand these dispositions and to make allowances for initiative and spontaneity, especially in the later stages of training. By maintaining a personal interest in his students he can better advise them as to their future, and often place them to advantage.

The graduate who intends to take up the career of a University teacher generally spends two or three years investigating a problem in one of the main branches of chemistry, under the general supervision of a professor. After that, he is fortunate if he secures a demonstratorship in a University or Technical College, from which, or at which, if he is capable, he may proceed to a higher appointment. His chances of success are improved if he shows aptitude for original investigation. Then, if the prospects of a career in industry do not dissuade him from teaching, he may eventually obtain a professorship. The number of such appointments is, however, very limited. Much gratuitous service in the public interest is expected of, and given by, chemists occupying such positions; a large proportion of their time is often spent on matters of educational organisation and administration connected with their institutions.

Many universities and colleges, particularly those in industrial centres, offer instruction in technological subjects, and there is an increasing tendency for such institutions to appoint teachers who have had practical experience in industry. It is generally realised that chemists with such experience are attracted to

teaching, either by personal considerations or by prospects comparable with those in industry.

The appointments of science masters in public, secondary and private schools, are, of course, very numerous, and many chemists have followed this branch of work, often from choice, but sometimes through lack of opportunities in other directions. There is a very distinct cleavage between University and School work. Transfer from the one to the other is exceptional, as the qualifications required differ in important respects. In University work, a high degree of scholarship and research ability are essential. In school work, a knowledge of chemistry up to the standard of a good honours degree is probably sufficient, but, in addition, definite training in teaching, and the possession of a teacher's diploma, are usually expected; few graduates can obtain a school appointment without both of these. The initial remuneration of junior teachers of science in schools is approximately equal to that offered to graduates on first obtaining industrial appointments; but promotion to higher posts in schools is often made on a basis of administrative ability and personality, rather than on actual scientific attainment. In many secondary schools there are advanced courses in science, including chemistry, designed to prepare pupils for the Higher School Certificate, for Intermediate Science, and for the competitive examinations for open scholarships at the universities. The standard of knowledge required in the last is very little below that required for degree examinations. From a chemist's point of view, teaching has been probably the least remunerative branch of the profession; yet, in the past, a very large proportion of graduates in science have become teachers in schools, although seldom having the opportunity of taking pupils beyond the standard required for the University Intermediate Examinations, and often not beyond that required for Matriculation, or the Schools Leaving Certificate.

Chapter XI

WOMEN IN PROFESSIONAL CHEMISTRY

Since the initiation of the movement for the higher education of women, the number of women students attracted to professional chemistry has steadily increased. Those who qualified in pre-war years usually found a career in the teaching profession or in research, and only to a limited extent in industry and private practice. The war, however, with its demand on all the chemical resources of the country, both personal and material, created opportunities for the employment of women in the laboratories of works, with the result that others having a liking for science have been encouraged to take up chemistry with the hope of finding employment in industry. A measure of this is afforded by a comparison of the numbers of women Fellows and Associates of the Institute of Chemistry before, during the period of, and since the war,—the Institute having been one of the first chartered professional bodies to admit women to the qualifying examinations:—

	Women Fellows.	Women Associates.	Total.
1914	4	1	5
1918	13	36	49
1935	27	174	201
1938	29	182	211

All that has been written in the earlier chapters on the training of chemists applies equally to women as to men. It involves a sound general education, followed by four years' technical training, including at least three years at a University or College, leading to an honours degree in chemistry and the equivalent of a pass degree in one or more subsidiary subjects, and eventually the Associateship of the Institute.

Women students of promise in many cases obtain scholarships to enable them to take full-time day courses and, therefore, the necessity of training by evening classes, which involves considerable strain, rarely arises.

Post-graduate experience in the methods of research is highly desirable as tending to cultivate the spirit of enquiry,

independent thought and criticism, which are invaluable alike to teachers and technical chemists, and may lead to the higher degrees of M.Sc. and Ph.D. For honours graduates the cost of this also may often be secured by scholarships or grants.

There is no *a priori* reason why women should not find employment in any of the classes of practice mentioned on pp. 32–33 except that many must, from force of circumstances, take any vacancy which may be offered to them. Some turn to secretarial work or to scientific journalism, but the majority take up teaching, for which they are often particularly suited. The work may be exacting and make a heavy demand on the teacher's mental and physical resources, but the hours are usually shorter and the holidays longer than those which are customary in other careers. These compensating factors cannot be ignored, and the leisure thus afforded may enable the teacher to find opportunities for carrying on further research.

A number of trained women chemists hold good appointments under the Research Associations of the various industries which are working in conjuction with the Department of Scientific and Industrial Research, or under the Research Boards controlled by Committees appointed by the Department. Others have obtained work in the research laboratories of the Medical Research Council and similar institutions.

In industry, and particularly in those industries where a large number of women are employed—such as food, margarine and jam factories—women are not infrequently engaged in analytical and research laboratories, but in other industries prospects for women are limited, because the higher positions call for experience in dealing with workmen, and, moreover, employers realise that, after a year or two, when the experience which a woman has gained in her work is becoming most valuable, her professional career may be terminated by marriage.

Chapter XII

SCIENTIFIC JOURNALISM AND AUTHORSHIP

To write well may be considered a gift, but any well-educated person should be able to acquire and maintain a correct and, possibly, even an attractive style by practice and constant reading of good literature. For scientific matter, an orderly and concise marshalling of facts and opinions is appreciated by those who know enough of the subject under review to be able to grasp the meaning easily; but the preparation of scientific articles, lectures or addresses, intended for the uninitiated, calls for even more ability.

Press articles consist usually of *news*—relating facts, and details with comments,—or *views*—setting forth opinions, followed by discussion and the conclusions thereon.

Popular articles on scientific subjects which can be readily understood by the man in the street are often attempted by writers who are better journalists than scientists and yet are disinclined to allow their work to be "vetted" by those who are better informed on the subject-matter. The result is often pitiable, and would sometimes be humorous, if it were not mischievous; indeed, it may constitute a real danger, as for example,—when greenstuff was getting scarce, during the war, a writer suggested using rhubarb leaves as a vegetable—with disastrous results.

Again, while a non-technical journalist may do harm by writing nonsense about science, an editor who alters an article from a scientific contributor, without his concurrence, may not only deceive the public, but injure the reputation of the author by misrepresenting his views.

For the practical man of science to devote all his time to writing would seem a misdirection of effort, but some who have suffered the misfortune of illness or accident which has prevented them from long-continued standing at the bench, and others from choice have taken to scientific journalism and authorship, abstracting, and the translation of foreign technical books.

The work is very various, and not infrequently very poorly remunerated, when all is considered; for often it happens that a few paragraphs only can be culled after hours of search for information on an out-of-the-way or abstruse subject, or a piece of

work that may seem of importanee to the writer is not appreciated when it reaches the editor or publisher.

Every scientific student, however, should cultivate the art of ready expression, and, if possible, something of style. He should be able to present in easy natural language a record of what he has been doing.

Beginning with examination exercises and the notes of his practical work, he may next have an opportunity of reading a paper before the chemical society of his college, and if he proceeds to a higher degree will have the experience of preparing a thesis.

Then, in professional life, in whatever branch the chemist may be working, he may prepare an occasional research paper. This may be valued more for the substance than for its wrappings, and bring no material reward for authorship. Papers contributed to scientific and learned societies are not here under consideration. If he aims at greater things, a textbook or a more ambitious technical work may be tackled, and may deserve recognition.

All such work is a legitimate and laudable method of becoming know, among his professional brethren, and is helpful in his career so long as it is good; but it should not be allowed to interfere unduly with his practical work. Rather should it come, by the way, as an ancillary accomplishment.

By itself, scientific writing can seldom afford a satisfactory livelihood except in the editorial chair, which is not often attained because of its rarity. The number of editorships for chemists is very limited. However, there are assistant-editorships and other well-paid appointments on journals of good standing, and these afford continuity of employment and prospects.

Comparatively few scientific and technical books are published in large editions, but they may materially assist in establishing the author's claim to recognition. Certain school and university textbooks and a few technical works dealing with great industries have, no doubt, been financially profitable, both to the authors and to the publishers; but many writers are disappointed after much labour and burning of midnight oil and expenditure of paper and ink.

> Shun—shun the Bowl! That fatal, facile drink
> Has ruined many geese who dipped their quills in't,
> Bribe, murder, marry, but steer clear of Ink
> Save when you write receipts for paid-up bills in't
> There may be silver in the "blue-black"—all
> I know of is the iron and the gall.
>
> "The Man Who Could Write"—
> Rudyard Kipling's *Departmental Ditties*.

For a good article of 1,000 or 1,500 words on a subject with a scientific basis, by a writer who is master of his matter and knows how to present it so that the average non-technical person when once he begins to read it will continue to the end, a daily newspaper should be prepared occasionally to pay not less than five guineas, and when the article is wanted it is well worth it.

To write such articles constantly and to find a ready market for them is another matter.

The rate of remuneration depends very much on the position and authority of the writer: substantial fees are often paid to eminent men for very little work, when the authors are named, but the editor, in any case, expects a fair return in both quality and quantity. Many papers pay by "line-age," and editors will usually be willing to arrange terms beforehand for contributions.

A useful note of less than half a column on a scientific subject of topical interest, by one who understands it himself and can make others understand it, may bring a couple of guineas. The daily press can take and pay for sound matter of the character, but the technical press, with far less circulation and advertisement revenue, cannot usually afford such rates, even for work of a more advanced character. Indeed, in this way well-known authorities—in signed articles—often supply valuable information to their co-workers, almost, if not entirely, gratuitously, and those who reap advantage therefrom incur a debt which can only be repaid by their following the same example.

To many scientific workers it is highly gratifying to have their work noticed and acknowledged. Such publication, under their names, often brings compensation indirectly; but where one may "rush into print" to obtain prior publication of some point of importance, another may be reluctant to tell all he knows of a subject, even where no particularly financial interests are involved, and may talk of having his "brains picked,"—having no thought for the time when the world may be left lacking his special knowledge.

In general, the occasional scientific writer should be paid for his work. He should have due regard to the undesirability of competing with the professional journalist, so far as the latter is concerned with matters of science and can cope with them adequately.

As to books and publishers—the expense involved in the production of a book renders an agreement necessary. Contracts

are prepared and the business is placed on a definite basis which may be modified according to the character and prospects of the work.

The publisher may buy the book outright, or offer a lump sum for the copyright, *plus* a royalty on the sales; or he may arrange to secure the copyright for an edition of a specified number of copies, pay all expenses of printing, production, advertising and distributing, and give the author, say 50 per cent. of the profits—if any; or he may undertake to pay all expenses and take all risks, and give the author a royalty of 10, 15 or more per cent. on all sales; or, if he is not very anxious to publish the work, he may require the author to participate in the initial cost before sharing in the profits,—if any.

A good book may bring its author credit, even though it may not be profitable financially; an inferior book, especially where science is concerned, cannot be of advantage to anybody.

Abstracting is an art in itself. It is sometimes suggested that the original author should be able to supply the best abstract. Probably much labour and expense would be saved if this practice could be generally adopted, but the best abstracts are prepared by those who not only understand the subject-matter but can regard it impartially. The preparation of scientific abstracts requires special knowledge of the matter to be abstracted, and discrimination in selecting the essential points,—especially those that are new or not generally known.

A translation, of course, should not be undertaken except by one who has a full knowledge of the substance of the article or book, a sound command of the particular foreign language, and of its idiom—lay and technical—and the faculty of patient concentration.

Reviews of books are often written gratuitously,—or sometimes in return for a copy of the work reviewed. It is a serious business, however, and should be paid for adequately, because it entails special knowledge, discretion and responsibility. Reviews are very generally restricted as to length; but the work should only be entrusted to unbiased and competent critics. Exceptionally, it may happen that the only really competent judge of the merchandise is the author himself. Indeed, in some classes of literature, the blurb, or dust-cover, with the preface, very frequently supply the review. A good journal cannot afford to publish reviews which are based on the judgment of

untrustworthy critics, for the opinions expressed may not only mislead the readers, but be very unfair and damaging to the authors.

The chemist who reviews the book of another engaged in the same branch of work may have a delicate task; indeed, if he does not approve of it, he may feel happier in declining to comment on it. In any case, a review which is not written in good faith can only be regarded as sheer insolence, and could hardly be accepted by a scientific publication without provoking a challenge.

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